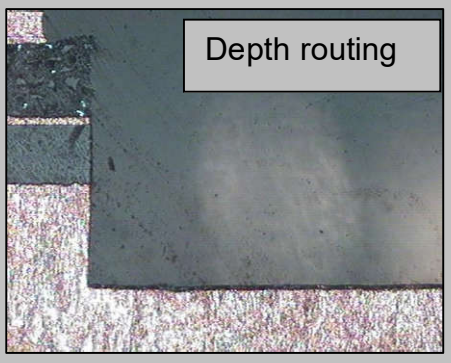
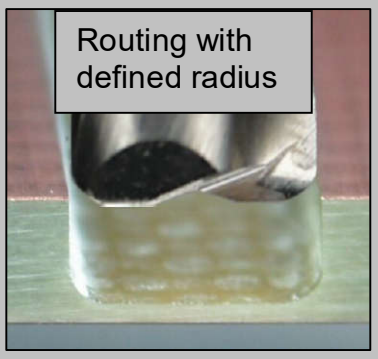
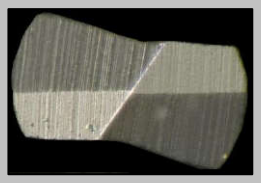
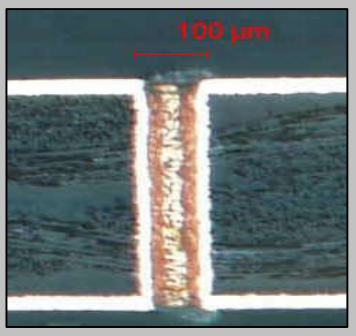
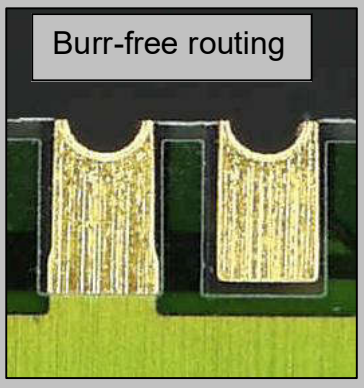


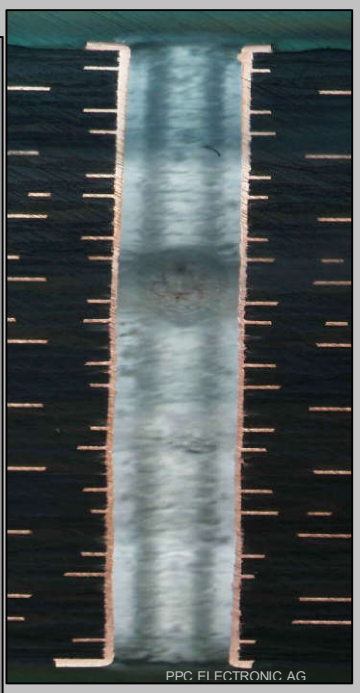


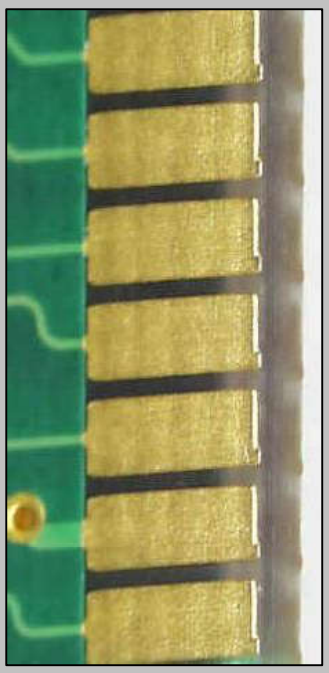


UMD
Ø 0,050 mm







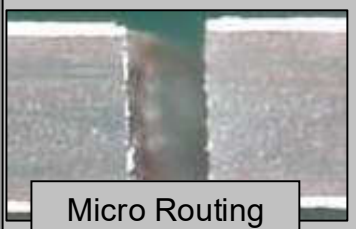


Application Center Ravensburg

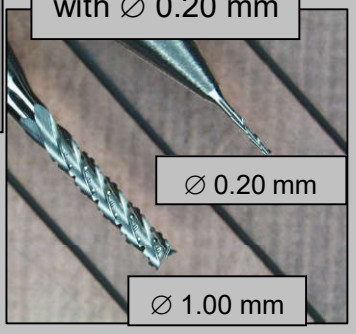
Drilling spindle	300.000 rpm
Routing spindle	125.000 rpm

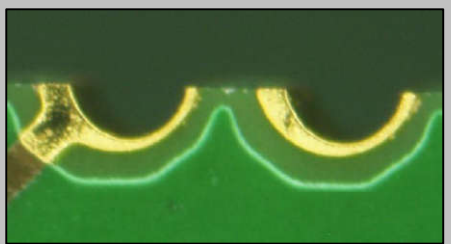
Application Center China (Kunshan)

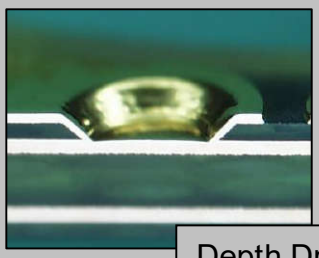
Drilling spindle	250.000 rpm
Routing spindle	125.000 rpm

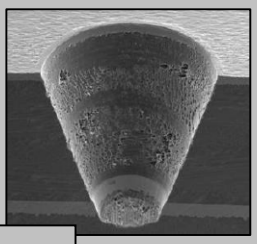


Micro Routing
with ∅ 0.20 mm

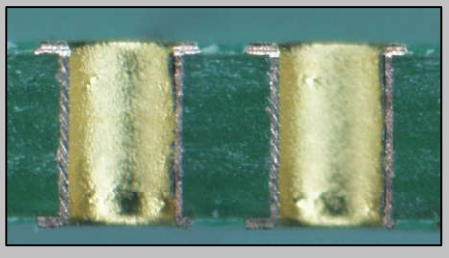


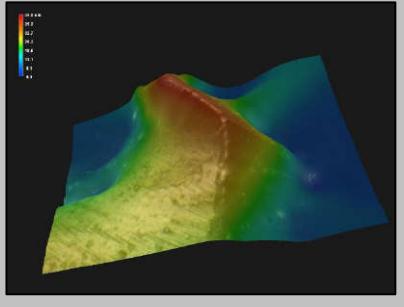






Depth Drilling





Survey of HPTec drills / application fields drills

tool type	description		Ø range [mm]	DS - ML 4 layers	ML 6-8 layers	ML ≥ 10 layers	ML ≥ 70 µm copper	Filled / HTG	Back-panels	Flex / Flex-rigid	Polyimide	Teflon	Metal core ML	Copper / Brass	PMMA / Plexiglas	remark
530	Standard drill		0.30 - 0.50	•	◑	◑	◑	•	◑	•	◑	◑	◑	•	◑	Universal for all standard applications.
			0.55 - 2.00	•	◑	◑	◑	◑	•	◑	•	•	•	•	◑	
			2.00 - 6.35	•	•	•	◑	•	•	•	◑	◑	◑	•	◑	
532	Chipbreaker / thinned web		3.175 - 6.50	•	•	•	•	•	•	•	◑	◑	◑	•	◑	
230	Multilayer drill	Spade type drill	0.25 - 2.00	•	•	•	◑	•	◑	◑	◑	•	◑	•	◑	Proved spade type drill for all multilayer boards.
218 212			0.105 - 0.15 0.20 - 0.65	•	•	•	•	◑	•	•	•	•	•	◑	•	Highest demands on hole wall quality + chip transport.
242			0.20 - 0.65	•	•	•	•	•	•	◑	•	•	◑	◑	◑	High performance drill. Excellent positioning accuracy and hole wall quality.
518 540		Standard	0.05 - 0.15 0.20 - 1.15	•	•	•	•	◑	•	•	•	•	•	•	•	Highest demands on hole wall quality + chip transport.
250	Slot drill	Spade type drill	0.50 - 2.50	•	•	•	◑	•	◑	◑	◑	◑	◑	◑	◑	Drilling slots
512	Flex drill	Standard	0.15 - 0.50	•	•	•	•	•	•	•	•	◑	•	•	•	Excellent positioning accuracy, long tool life, more regrinding cycles possible.
596	Microvia drill	Conical	0.075 - 0.40	•	•	•	•	•	•	•	◑	◑	◑	◑	◑	Drill for conical blind via holes.

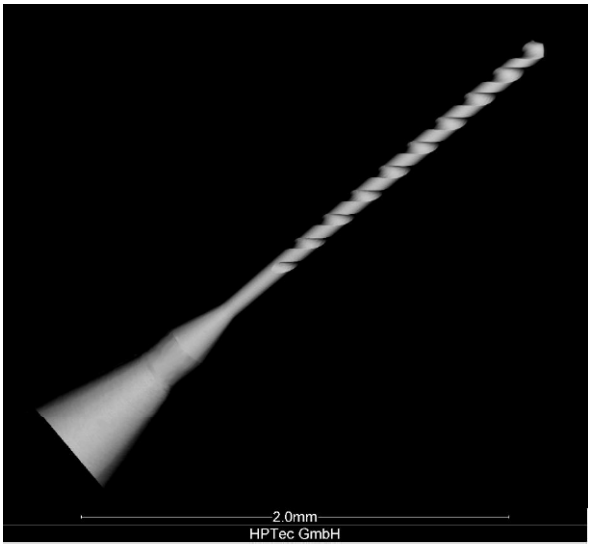
Key:
optimum = •
suitable = ◑
not recommendable = **O**

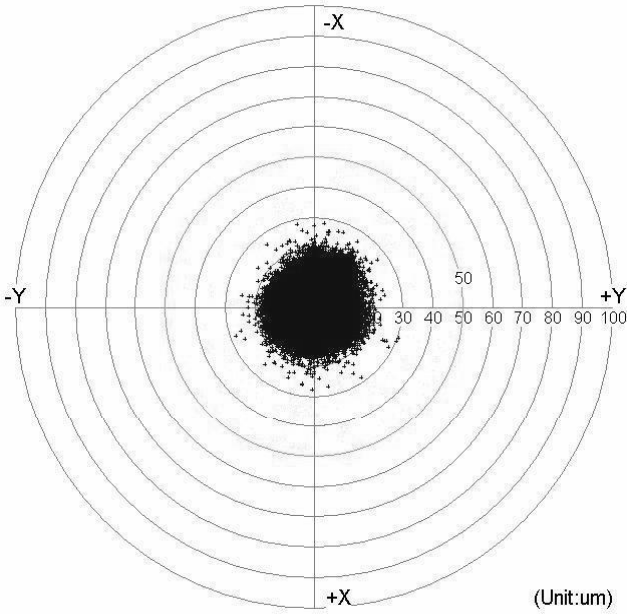
ULTRAMICROBOHRER Typen und Spirallängen
ULTRA MICRO DRILLS Types and Flute Lengths

Ø [mm]	512 Flex-bohrer Flex Drill	518 / 418* Standard-bohrer Standard Drill	218 / 318* Kopf-bohrer Spade Type Drill	596 Microvia-Bohrer Microvia Drill
0,050		0,6*		
0,075		1,0		
0,100		1,5		
0,105		1,8	1,6	
0,110		1,8	1,6	
0,120		2,0	2,0	0,5
0,150	2,5	2,5	2,5	0,5*
0,20 / 0,25	3,5			1,0
0,30 / 0,35*	5,5			2,5
0,40				2,5

Ø > 0,15 mm siehe Übersicht Micro-/Standardbohrer
Ø > 0,15 mm see survey Micro/Standard Drills

*** auf Anfrage** — **418 / 318 Schaftdurchmesser = 2 mm**
*** on request** — **418 / 318 shank diameter = 2 mm**





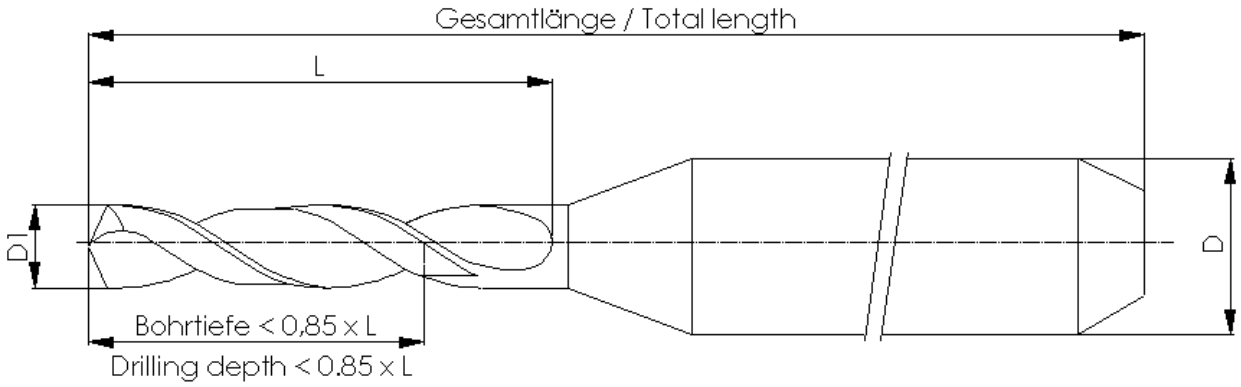
BGA

BT-Material:	**0.1 mm 2 x 6 µm Cu**
Stack height:	**6 up**
Entry:	**LE-800**
Backup:	**coated wood**
Hits:	**3000**
Parameter:	**s = 200.000rpm**
	F = 35 mm/s
	R = 250 mm/s

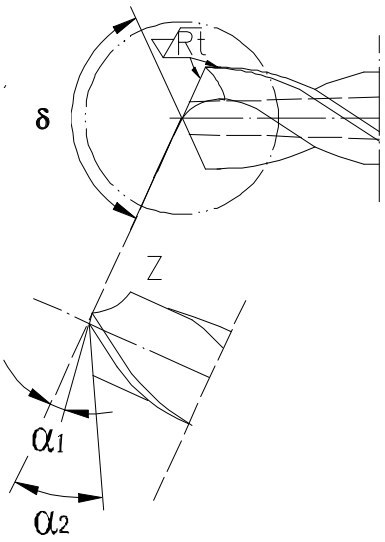
MICRO-/STANDARDBOHRER Typen und Spirallängen
MICRO / STANDARD DRILLS Types and Flute Lengths

Ø [mm]	512	530	230	212	242	540	250
	Flex-bohrer	Standard-bohrer	Kopf-bohrer	Multilayer-bohrer			Langloch-bohrer
	Flex Drill	Standard Drill	Spade Type Drill	Multilayer Drill			Slot Drill
	Ø ≤ 0,2 mm siehe Übersicht *ULTRAMICROBOHRER* Ø ≤ 0,2 mm see survey *ULTRA MICRO DRILLS*						
	* auf Anfrage * on request						
0,15	2,5						
0,20	3,5			3,5	3,5 / 4,0	3,2 / 4,0*	
0,25	3,5		3,5	4	4,0 / 4,5	3,2* / 4,0*	
0,30	5,5	5,5	5,5	5,5 / 6,5*	5,5 / 6,5*	5,5*	
0,35	*	5,5 / 7	5,5 / 7	5,5 / 7	7	5,5* / 7*	
0,40	*	5,5 / 7	5,5 / 7	5,5 / 7 / 8,5*	7	5,5* / 7*	
0,45	*	7	5,5* / 7	7 / 8,5*	7	7*	
0,50	*	7 / 8,5	7 / 8,5*	7 / 8,5	7	7*	5,5 / 7
0,55		7 / 8,5	7 / 8,5	8,5	7	7*	5,5 / 7
0,60		7 / 8,5	7 / 8,5	8,5	8,5	7*	5,5 / 7
0,65		7* / 8,5	7 / 8,5	8,5	8,5	7*	5,5 / 7
0,70		10,5	10			8,5*	7 / 8,5
0,75		10,5	10			8,5*	7 / 8,5
⋮		⋮	⋮			⋮	⋮
0,85		10,5	10			8,5*	7 / 8,5
0,90		10,5	10			9,5*	7 / 8,5
0,95		10,5	10			9,5*	7 / 8,5
1,00		10,5	10			10,5*	8,5
⋮		⋮	⋮			⋮	⋮
1,15		10,5	10			10,5*	8,5
1,20		10,5	10				8,5
1,25		10,5	10				8,5
⋮		⋮	⋮				⋮
1,60		10,5	10				8,5
1,65		10,5	10				8,5
⋮		⋮	⋮				⋮
2,00		10,5	10				8,5
⋮		⋮					⋮
2,50		10,5					8,5
⋮		⋮					
3,175		10,5					
3,20		12					
⋮		⋮					
6,35		12					

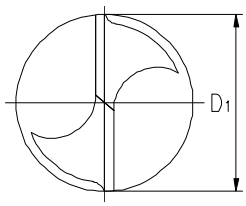
Spezifikation für Spiralbohrer 212/218/230/242/250/512/518/530/540
Specification for drills



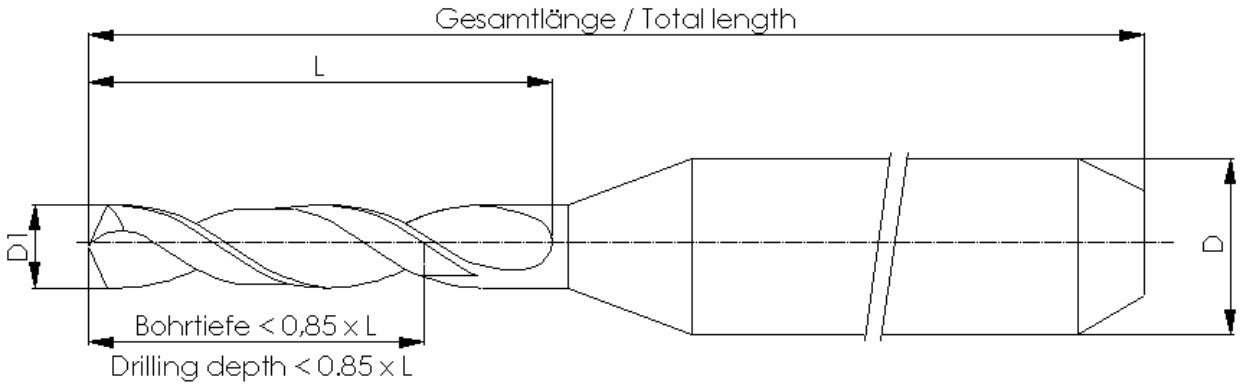
	$0,05 < D_1 < D$	$D_1 > D$
Gesamtlänge / Total length	**38,2 -0,2**	**38,2 -0,3**
Spirallänge / Flute length		
L ≤ 2	**+0,2 / -0,1**	
2 < L < 10	**+0,4 / -0,2**	
L ≥ 10	**+0,4 / -0,2**	**+0,5 / -0,3**
Schneidenrauhtiefe R_t / Roughness R_t	**< 0,003**	**< 0,005**
Schaft- / shank ∅ D	**-0,001 / -0,007**	**-0,001 / -0,01**



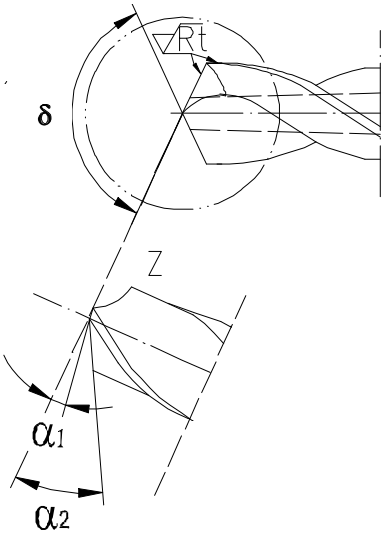
Nenn- / Nominal-∅ D_1	
0,05 ≤ 0,25	**+0,000 /+0,008**
0,26 ≤ 1,65	**+0,000 / -0,008**
1,66 - 3,175	**+0,000 / -0,012**
≥ 3,20	**+0,000 / -0,015**
	Angaben / Data in [mm]
Spitzenwinkel δ / Point angle δ	
0,05 < D_1 ≤ 0,12	**130 -5**
0,12 < D_1 ≤ 0,20	**120 -5**
0,20 < D_1 ≤ 3,175	**130 -5**
D_1 > 3,175	**165 -5**
Typ 250	**150 -5**
1. Freiwinkel α_1 / Primary face angle α_1	
D_1 0,05 – 0,20	**10 -3**
0,21 – 6,50	**15 -5**
2. Freiwinkel α_2 / Secondary face angle α_2	
D_1 0,05 – 6,50	**30 -5**
	Angaben / Data in [°]



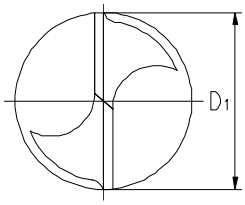
Spezifikation für Spiralbohrer 318/418
Specification for drills

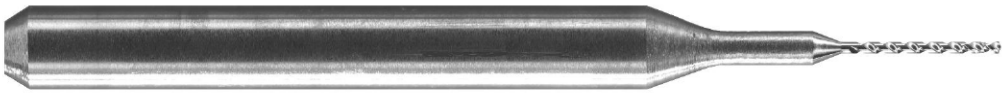


	$0,05 < D_1 < D$	$D_1 > D$
Gesamtlänge / Total length	**31,85 -0,2**	**31,85 -0,3**
Spirallänge / Flute length		
L ≤ 2	**+0,2 / -0,1**	
2 < L < 10	**+0,4 / -0,2**	
L ≥ 10	**+0,4 / -0,2**	**+0,5 / -0,3**
Schneidenrauhtiefe R_t / Roughness R_t	**< 0,003**	**< 0,005**
Schaft- / shank ∅ D	**-0,001 / -0,007**	**-0,001 / -0,01**



Nenn- / Nominal-∅ D_1	
0,05 ≤ 0,25	**+0,000 /+0,008**
0,26 ≤ 1,65	**+0,000 / -0,008**
1,66 – 1.99	**+0,000 / -0,012**
≥ 2.00	**+0,000 / -0,015**
	Angaben / Data in [mm]
Spitzenwinkel δ / Point angle δ	
0,05 < D_1 ≤ 0,12	**130 -5**
0,12 < D_1 ≤ 0,20	**120 -5**
0,20 < D_1 ≤ 3,175	**130 -5**
D_1 > 3,175	**165 -5**
1. Freiwinkel α_1 / Primary face angle α_1	
D_1 0,05 – 0,20	**10 -3**
0,21 – 6,50	**15 -5**
2. Freiwinkel α_2 / Secondary face angle α_2	
D_1 0,05 – 6,50	**30 -5**
	Angaben / Data in [°]





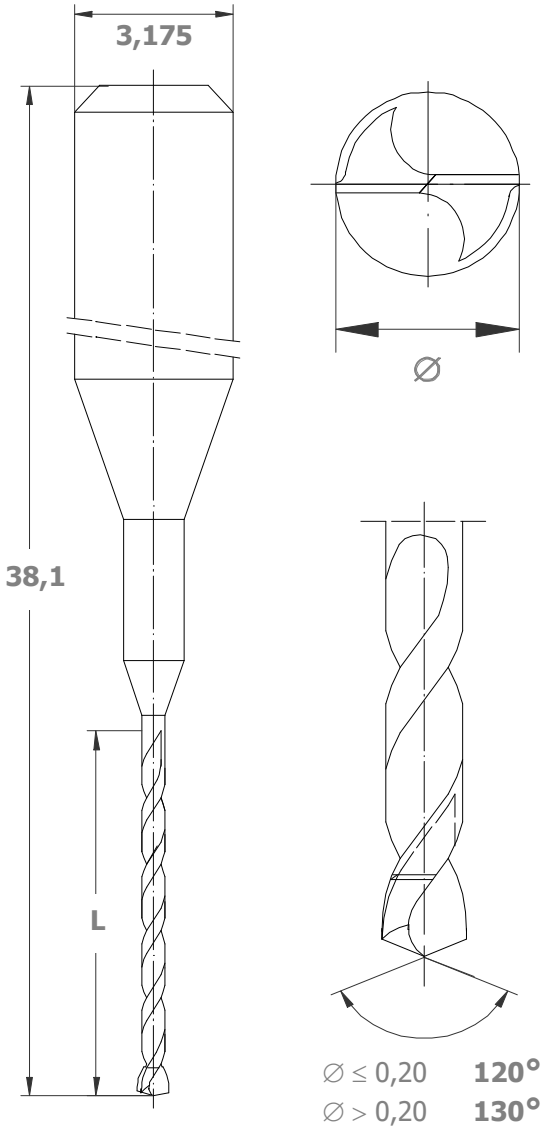
212

Multilayerbohrer, Kopfbohrergeometrie
Anwendung/Vorteile:

- **Bohren von hochlagigen Multilayern**
- **Verbesserung der Lochqualität**

Multilayer drill, spade type version
Application/Advantages:

- **drilling of high layer boards**
- **improvement of hole quality**



∅ ≤ 0,20 **120°**
∅ > 0,20 **130°**

212						
∅ [mm]	L [mm] 3,5	4,0	5,5	6,5	7,0	8,5
0,20	x					
0,25		x				
0,30			x	x*		
0,35			x		x	
0,40			x		x	x*
0,45					x	x*
0,50					x	x
0,55						x
0,60						x
0,65						x

* auf Anfrage * on request

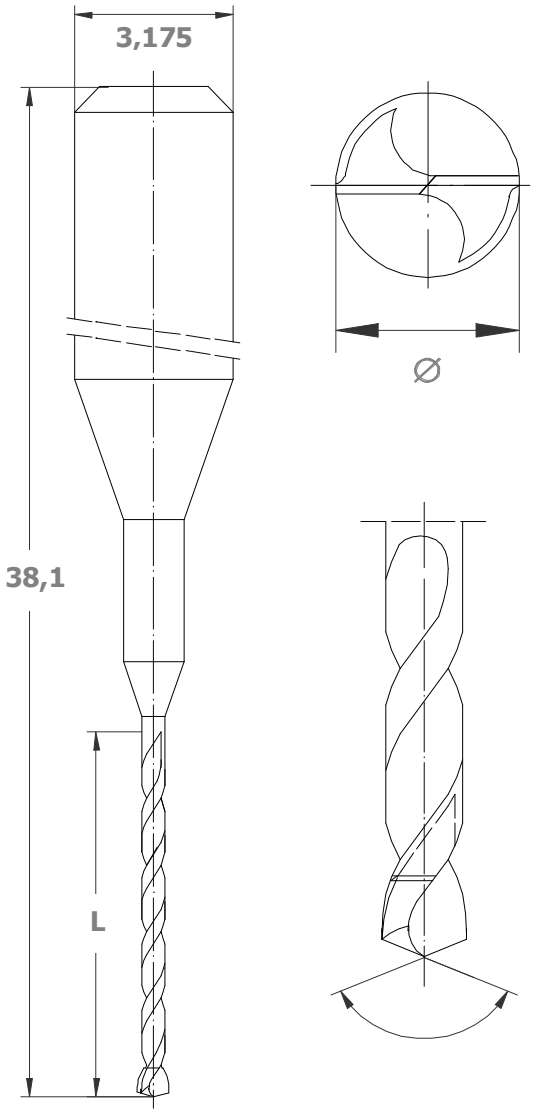
218
318

Ultramicrobohrer,
Kopfbohrergeometrie
für hochdrehende Spindeln
Anwendung/Vorteile:

- **BGA / HDI**
- **höchste Stabilität**
- **höchste Bohrgenauigkeit**

Ultra micro drill,
spade type version
for high speed spindles
Application/Advantages:

- **BGA / HDI**
- **best stability**
- **best accuracy**



218			
Ø [mm]	L [mm] 1,6	2,0	2,5
0,105	x		
0,110	x		
0,120		x	
0,150			x

Auf Anfrage Typ 318 mit Schaftdurchmesser 2,0 mm / Gesamtlänge 32 mm erhältlich.

On request type 318 with shank diameter 2,0 mm / total length 32 mm available.

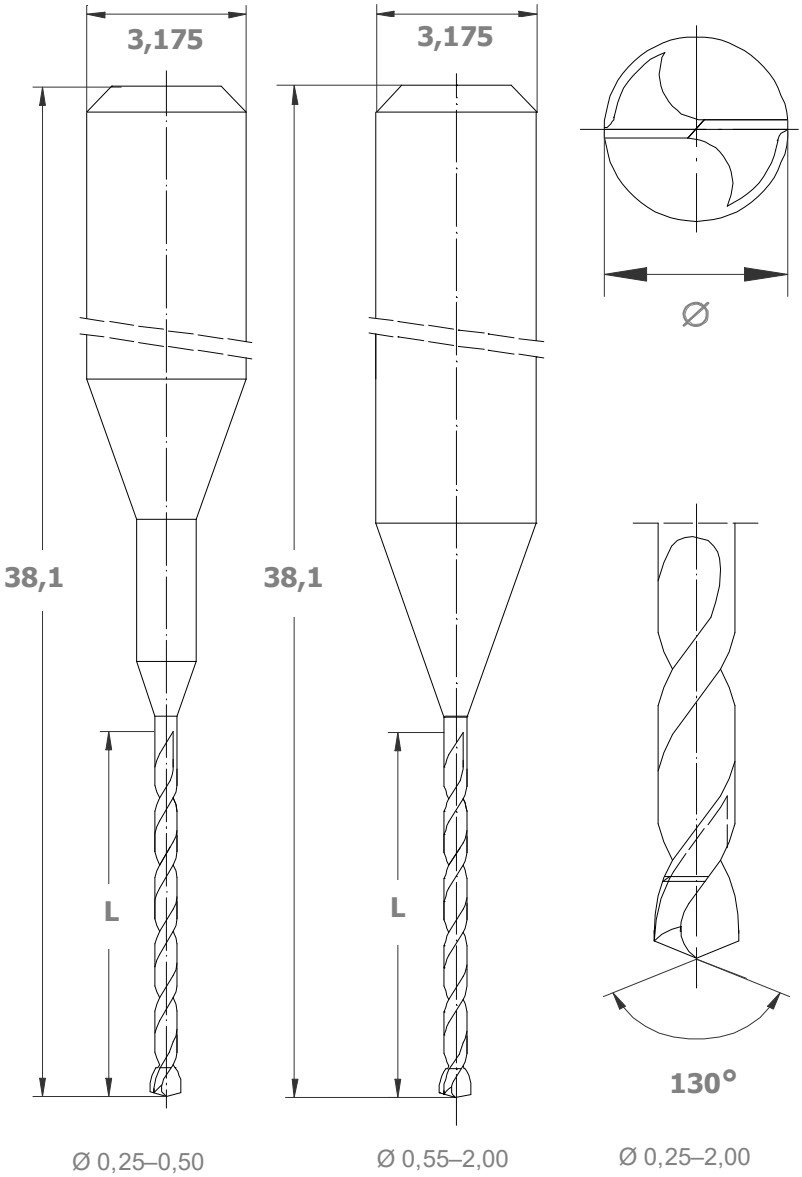
230

Kopfbohrer
Anwendung/Vorteile:

- **Bohren von anspruchsvollen Multilayern**
- **sehr gute Lochqualität bei geringem Bohrerverlauf durch optimierte Geometrie**

Spade type drill
Application/Advantages:

- **drilling of high-quality multilayer boards**
- **excellent hole quality by less drill deflection due to optimised undercut geometry**



230				
Ø [mm]	L [mm] 3,5	5,5	7,0	8,5
0,25	x			
0,30		x		
0,35		x	x	
0,40		x	x	
0,45		x*	x	
0,50			x	x*
0,55			x	x
0,60			x	x
0,65			x	x

Ø [mm]	L [mm] 10,0
0,70	x
0,75	x
0,80	x
:	:
1,60	x
1,65	x
:	:
2,00	x

* auf Anfrage * on request

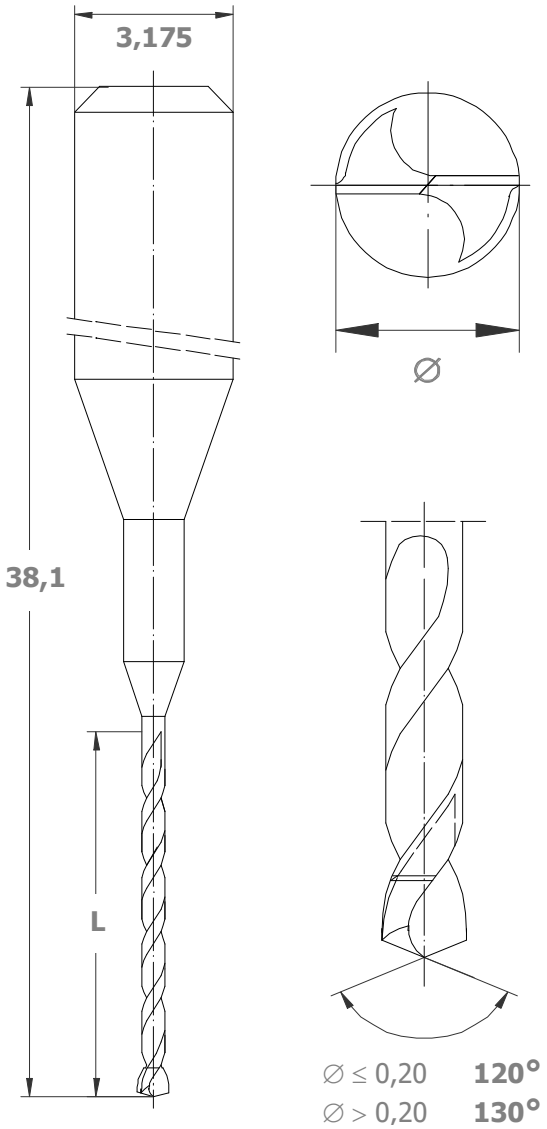
242

Multilayerbohrer, Kopfbohrergeometrie
Anwendung/Vorteile:

- **maximale Stabilität**
- **verbesserter Bohrerverlauf**
- **geringere Bohrkosten durch mehrmaliges Nachschleifen**

Multilayer drill, spade type version
Application/Advantages:

- **maximum stability**
- **improved drill deviation**
- **less cost due to several regrinding cycles**



∅ ≤ 0,20 **120°**
∅ > 0,20 **130°**

242							
∅ [mm]	L [mm] 3,5	4,0	4,5	5,5	6,5	7,0	8,5
0,20	x	x					
0,25		x	x				
0,30				x	x*		
0,35				x	x	x	
0,40						x	
0,45						x	
0,50						x	
0,55						x	
0,60							x
0,65							x

* auf Anfrage * on request

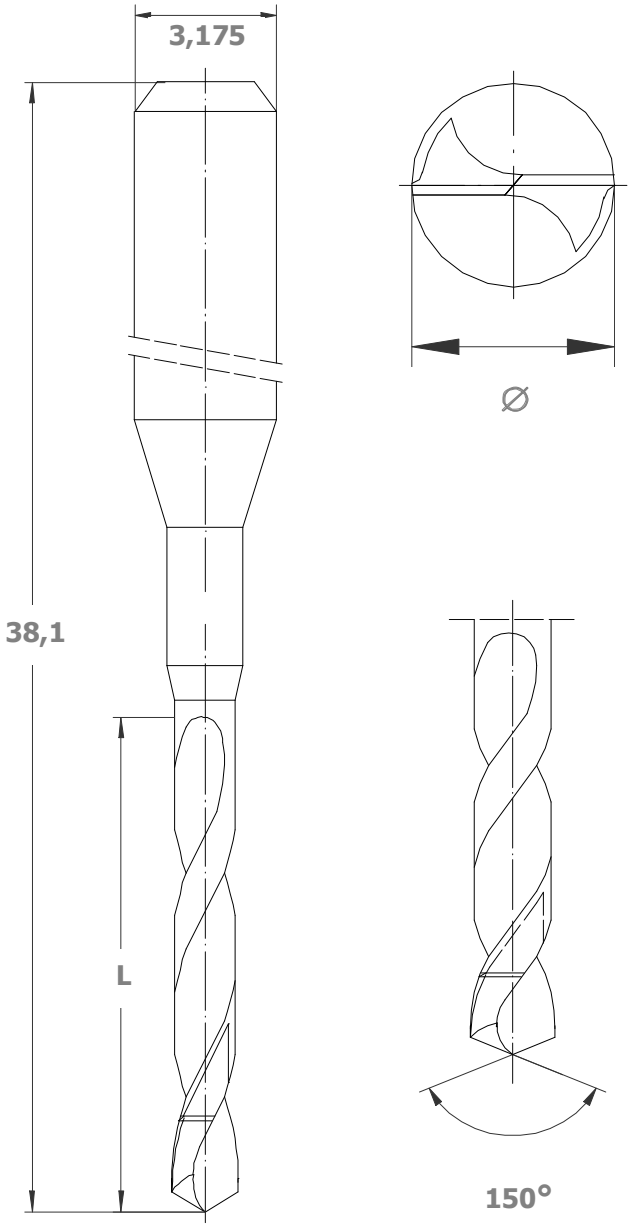
250

Langlochbohrer
Anwendung:

- **Bohren (Nippeln) von Langlöchern und Schlitzen**

Slot drill
Application:

- **drilling slots**



250			
Ø [mm]	L [mm] 5,5	7,0	8,5
0,50	x	x	
0,55	x	x	
0,60	x	x	
0,65	x	x	
0,70		x	x
0,75		x	x
0,80		x	x
0,85		x	x
0,90		x	x
0,95		x	x
1,00			x
:			:
1,25			x
1,30			x
:			:
2,50			x

* weitere Durchmesser und Spirallängen auf Anfrage

* other diameters and flute lengths on request

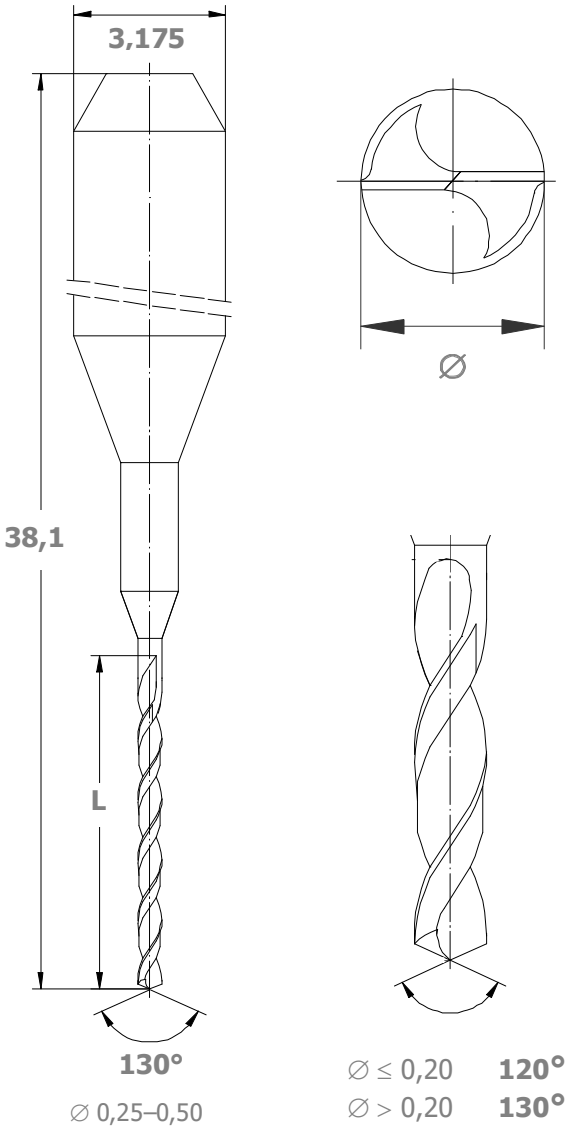
512

Flexbohrer
Anwendung/Vorteile:

- **hoch produktive Bearbeitung von flexiblen und starr-flexiblen Multilayern**
- **optimale Bohrlochqualität**
- **Reduzierung von Nagelkopfbildung und Grat**

Flex drill
Application/Advantages:

- **drilling of flex and flex rigid boards**
- **improvement of hole quality**
- **reduction of nail heading**



512			
∅ [mm]	L [mm] 2,5	3,5	5,5
0,15	x		
0,20		x	
0,25		x	
0,30			X
0,35*			
0,40*			
0,45*			
0,50*			

* weitere Durchmesser und Spirallängen auf Anfrage

* other diameters and flute lengths on request

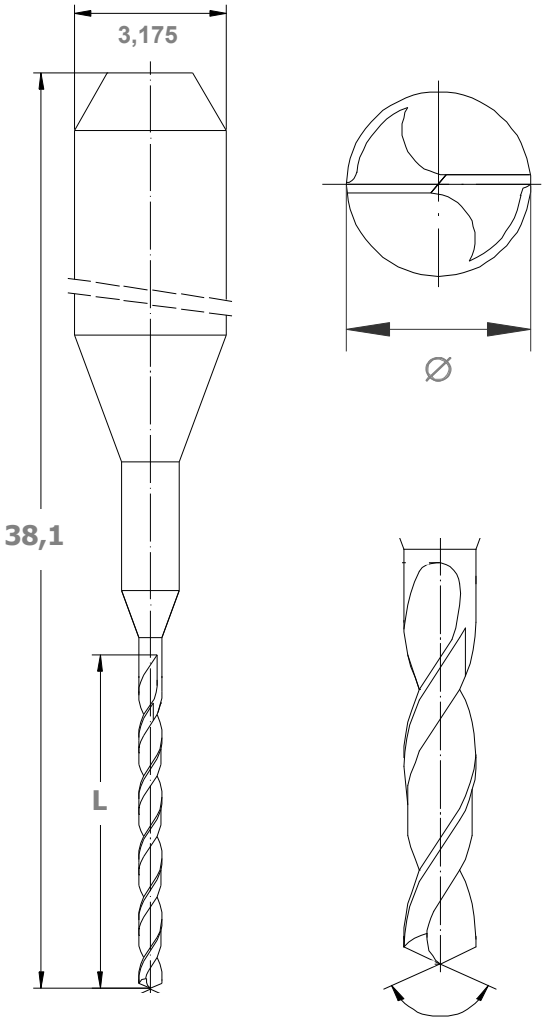
518
418

Ultramicrobohrer,
Standardbohrergeometrie
für hochdrehende Spindeln
Anwendung/Vorteile:

- **BGA / HDI**
- **höchste Stabilität**
- **höchste Bohrgenauigkeit**

Ultra micro drill,
standard geometry
for high speed spindles
Application/Advantages:

- **BGA / HDI**
- **best stability**
- **best accuracy**



518						
Ø [mm]	L [mm] 0,6	1,0	1,5	1,8	2,0	2,5
0,050	x*					
0,075		x				
0,100			x			
0,105				x		
0,110				x		
0,120					x	
0,150						x

* auf Anfrage * on request

Auf Anfrage Typ 418 mit Schaftdurchmesser 2,0 mm / Gesamtlänge 32 mm erhältlich.

On request type 418 with shank diameter 2,0 mm / total length 32 mm available.

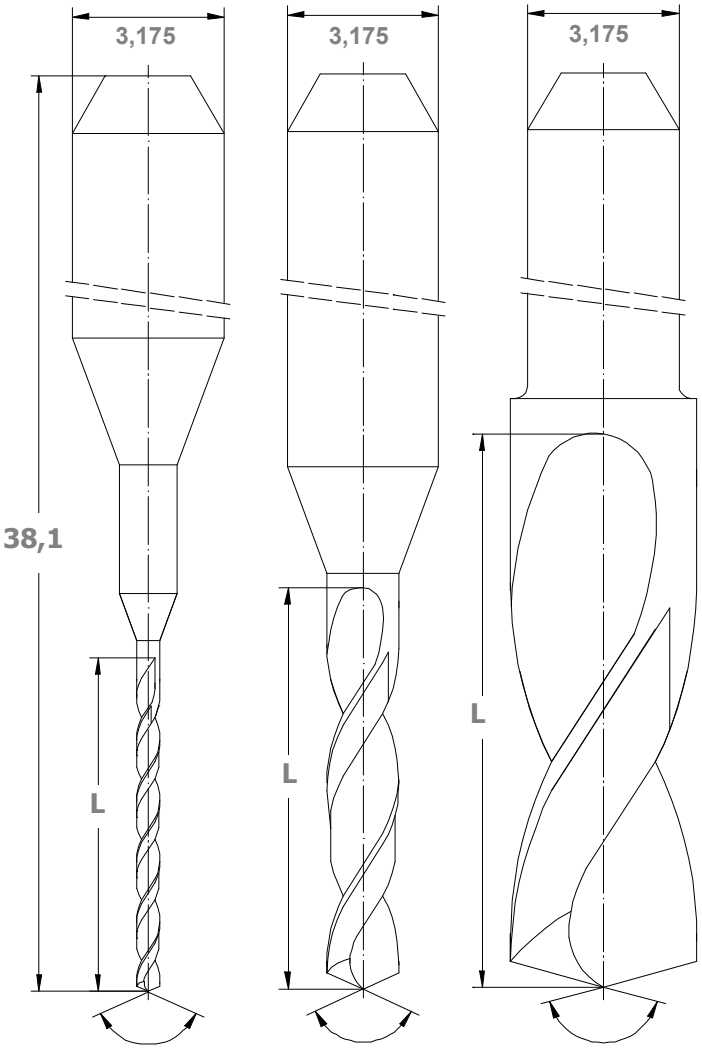
530

Spiralbohrer
Anwendung:

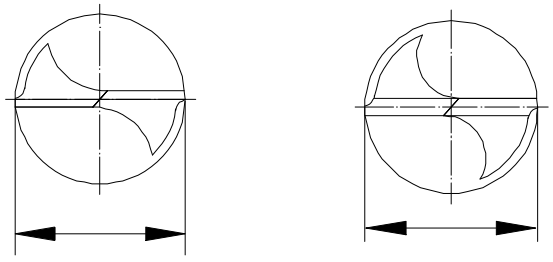
- **für alle Standardprodukte**

Standard drill
Application:

- **for all standard products**



∅ 0,30–0,50 ∅ 0,55–3,175 ∅ 3,20–6,35



∅ 0,30-3,175 ∅ 3,2-6,35

530			
∅ [mm]	L [mm] 5,5	7,0	8,5
0,30	x		
0,35	x	x	
0,40	x	x	
0,45		x	
0,50		x	x
0,55		x	x
0,60		x	x
0,65		x*	x

∅ [mm]	L [mm] 10,5	12
0,70	x	
0,75	x	
0,80	x	
:	:	
3,15	x	
3,175	x	
3,20		x
3,25		x
:		:
6,35		x

* auf Anfrage * on request

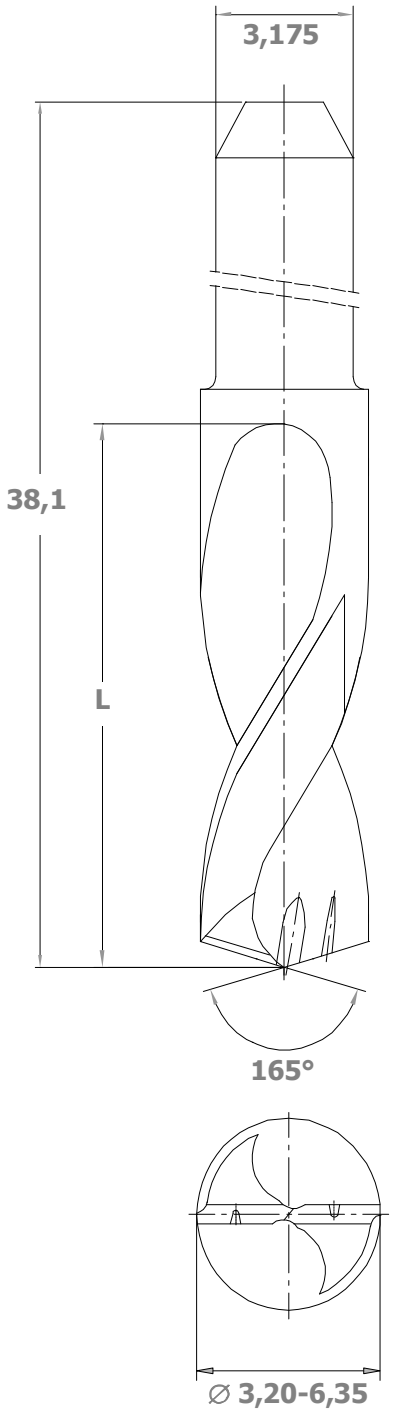
532

Spiralbohrer mit ausgespitztem Kern und Spanbrecher
Anwendung:

- **Dick-Kupferanwendungen**
- **für langspanende Werkstoffe**

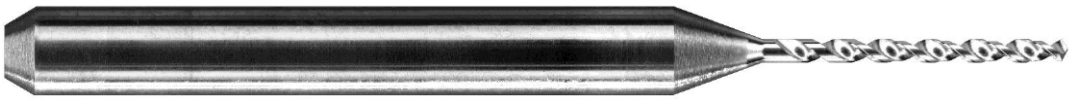
Standard drill with thinned web and chip breaker
Application:

- **thick copper applications**
- **long-chipping materials**



532	
∅ [mm]	L [mm] 12
3,50	x
3,55	x
3,95	x
4,05	x
4,10	x
4,20	x
4,25	x
4,30	x
4,60	x
4,65	x
4,80	x
4,85	x
5,00	x
5,05	x
5,85	x
6,05	x
6,30	x

Bemerkung:
Andere Durchmesser auf Anfrage.
Remark:
Other diameters on request.



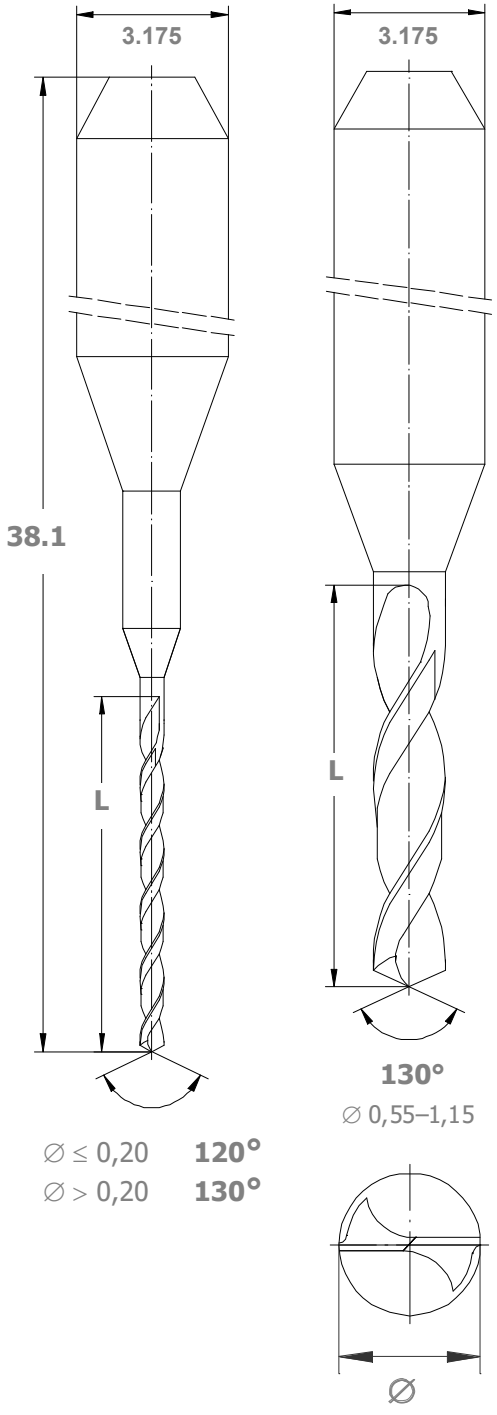
540

Multilayerbohrer
Anwendung/Vorteile:

- **Bohren von hochlagigen / dicken Multilayern**
- **Verbesserung der Bohrlochqualität**

Multilayer drill
Application/Advantages:

- **drilling of high layer boards**
- **drilling of thick panels**
- **improvement of hole quality**



∅ ≤ 0,20 **120°**
∅ > 0,20 **130°**

540				
∅ [mm]	L [mm] 3,2	4,0	5,5	7,0
0,20	x	x*		
0,25	x*	x*		
0,30			x*	
0,35			x*	x*
0,40			x*	x*
0,45				x*
0,50				x*

∅ [mm]	L [mm] 7,0	8,5	9,5	10,5
0,55	x*			
0,60	x*			
0,65	x*			
0,70		x*		
0,75		x*		
0,80		x*		
0,85		x*		
0,90			x*	
0,95			x*	
1,00				x*
1,05				x*
1,10				x*
1,15				x*

* auf Anfrage * on request

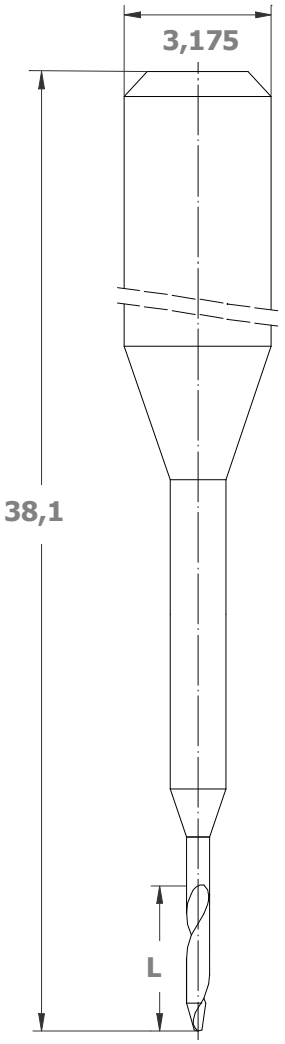
596

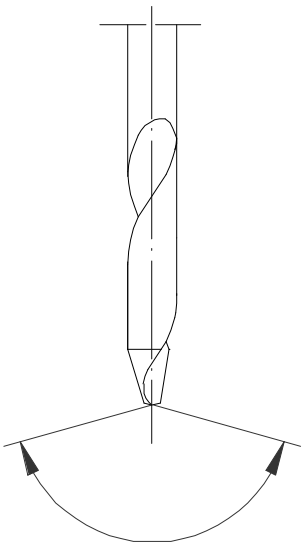
Microvia-Bohrer mit konischem Außendurchmesser
Anwendung/Vorteile:

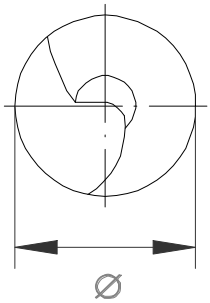
- **Bohren von Microvias (Sacklöchern)**
- **sehr gute Lochqualität und Positionsgenauigkeit**

Microvia drill with tapered outer diameter
Application/Advantages:

- **drilling of microvias (blind holes)**
- **excellent hole quality and high position accuracy**







Typ 596 Ø 0,12:
Maximale Bohrtiefe 120 µm

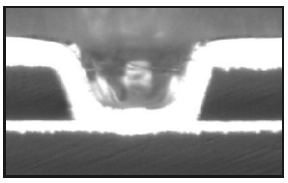
Type 596 Ø 0,12:
Maximum drilling depth 120 µm

Typ 596 Ø 0,4:
Maximale Bohrtiefe 400 µm

Type 596 Ø 0,4:
Maximum drilling depth 400 µm

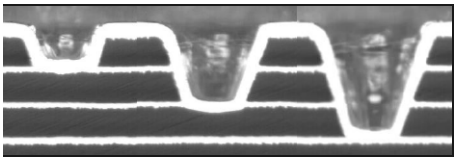
596			
Ø [mm]	L [mm]		
	0,5	1,0	2,5
0,12	x		
0,15	x*		
0,20		x	
0,25		x	
0,30			x
0,35			x
0,40			x

Bemerkung:
Andere Durchmesser auf Anfrage.
Remark:
Other diameters on request.



Mechanisch gebohrtes Sackloch auf die erste Innenlage.

Mechanical drilled microvia to the first inner layer.



Mechanisch gebohrte Sacklöcher auf drei Innenlagen.
Mechanical drilled microvias to three inner layers.

Survey of HPTec routers / application fields routers

tool type	description	FR 4 oc	FR 4 ic	FR 2	CEM 1 CEM 3	Filled / HTG	PE	PTFE	PMMA	Polyimide	Flex / Rigid Flex	Al	Cu / brass	Metal composite laminates	remark
626	diamond-patterned teeth	•	•	•	•	•								•	standard contour router
726 790	spiral-patterned teeth	•	•	•	•	• •					•			•	standard contour router good chip transport and edge quality
817 818	1-flute		•	•	•		•	•	•	•	• •	• •	•	•	very good edge quality, burr-free and for soft and flexible materials
826 827 828	2-flute		•	•	•	•	•	•	•	•	• • •	•	• • •	•	all-purpose tool for working with plastics and metals
836	3-flute		•	•	•	•	•	•	•	•	•		•	•	for metallised slots
80X	V-groove cutter	•		•	•	•	•	•	•	•	•	•	•	•	good chip transport and edge quality
850	Countersink	•		•	•	•	•	•	•	•		•	•	•	chamfering of PCBs
876	Contour finishing	•		•	•	•	•	•	•	•	•	•	•	•	burr free routing (goldfingers)
891	2-flute	•		•	•		•	•	•	•		•	•	•	good chip transport and edge quality

parameters													
cutting speed v_s [m/min]	190-220		160-180	160-180	110-170	100-120	100-120	110-130	100-120	80-120	200-250	180-220	100-125
Ø [mm]	**oc**	**ic**	**chip load [µm/1]**										
1,0	8	8	10	10	8-12	10	10	20	10	8	3	3	2
1,2	12	10	14	14	12-16	14	14	30	14	12	5	5	3
1,6	20	15	25	25	22-26	25	25	40	25	23	8	8	4
2,0	38	30	45	45	40-48	35	35	50	35	32	12	12	4
2,4	48	34	55	55	50-60	40	40	60	40	35	15	15	5

Cutting speed and chip load are basic recommendations depending on the material specification.

Parameters have to be adjusted accordingly.

Key:

optimal material = •

possible alternative = **O**

ic = inner contour

oc = outer contour

Formula: spindle speed n [rpm]

$n = v_s * 1000 / (3.14 * \varnothing)$

feed rate F [m/min]

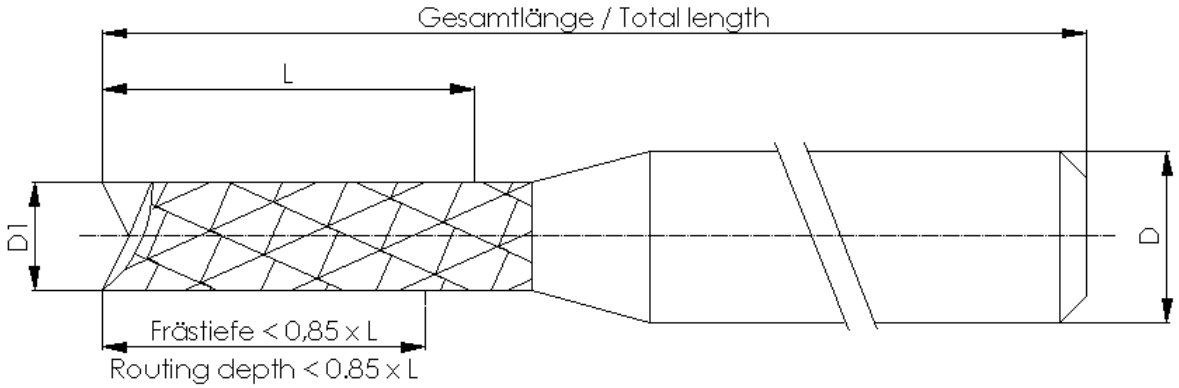
$F = f * n$

$f = F / n$ [µm/rev]

Standardfräser Übersicht / Survey of Standard Routers

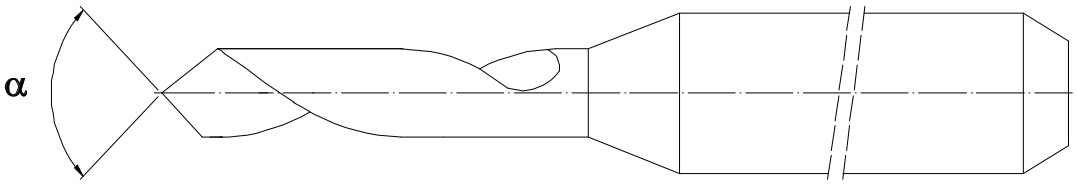
Ø												
in	diamantverzahnt	spiralverzahnt		1-Schneider		2-Schneider				3-Schneider	Schlichtfräser	Ritzstichel						Kegelsenker
[mm]	diamond-patterned teeth	spiral-patterned teeth		1-flute		2-flute				3-flute	finishing router	V-groove cutter						Countersink
	626	726	790	818	817	826	828	827	891	836	876	801	802	803	804	806	809	850
			beschichtet / coated				Tiefenfräser / depth router	Tiefenfräser / depth router	beschichtet / coated									
0,20						0,7*	0,7*					point angle						point angle
0,25						1*	1*					22°	30°	30°	45°	60°	90°	90°/120°/140°
0,3						1*	1*											
0,4			3,5	1,5		1,5*	1,5*											
0,5		3	2,5	3		3	3											
0,6		3	3 / 4	3		3	3	3*										
0,7		3,5	3,5	3		3	3	3*										
0,8		5	5	3		5	5	5*										
0,9		5		3		5	5	5*	4*									
1,0	7	7 / 8,5*	5,2 / 6,5	3	3	5	5	5	3 / 4*	5*								
1,1	7	7 / 8,5*	6,5	3*	3*	5	5	5*	3*	5*								
1,2	7	7 / 8,5*	6,0 / 7,0	4	4	5	5	5	3* / 4*	5*								
1,3	7	7 / 8,5*	6,0 / 7,0	4*	4*	5	5	5*	3*	5*								
1,4	7	7 / 8,5*	7,0	4	4*	5	5	5*	3* / 4*	5*								
1,5	8	8,5	7,5	4	4*	6	6	6*	4* / 6	7*								
1,6	8	8,5	7,5 / 8,5	5	5	6	6	6	6*	7*	7*							
1,7	8	8,5		5*	5*	6	6	6*	6*	7*								
1,8	8	8,5	7,5 / 8,5	5*	5*	6	6	6*	4* / 6*	7*								
1,9	8	8,5	8,5	5*	5*	6	6	6*	6*	7*								
2,0	8 / 10	9	7,5 / 9,0	8	8	8	8	8	4* / 6	9*	7*		x	x	x			
2,1	8	9*				8	8	8*	6*									
2,2	8	9*				8	8	8*	6*									
2,3	8	9*				8	8	8*	6*									
2,4	8 / 10	9	9,0	8	8	8	8	8	6	9*	7*	* auf Anfrage				x		
2,5	8	9	9,0			8	8	8*	6*			* on request						
3,0	10*	9	9,0	9	9	10	10	10	6									
3,175	10*	9		9*	9*	10	10	10*	6*			x					x	
6,0																		x

Spezifikation für Fräser **620/624/626**
Specification for routers **720/724/726/790**
802/803/804/806/809
817/818/826/827/828/836/850/876/891

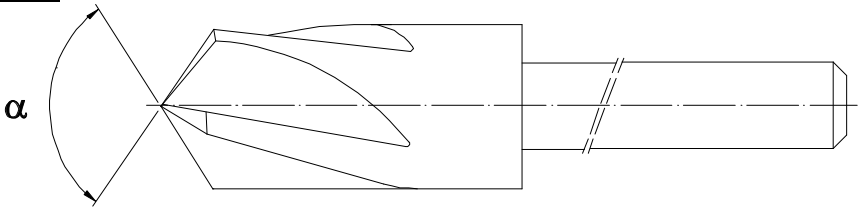


Gesamtlänge / Total Length		**38,2 –0,4**
Spirallänge / Flute Length	**L**	**+0,6 / -0,1**
Schaft- / Shank-∅	**D**	**-0,001/-0,007**
Nenn- / Nominal-∅ **wenn / if D_1 = D** **Typ / Type 836**	**D_1**	**+0,01/-0,02** **0/-0,04** **+0,01/-0,03**
Schneidenschartigkeit / Roughness		**≤ 0,006**
Ausbrüche / Chips		**≤ 0,030 max. 10 %** **der Einzelschneiden eines Fräsers /** **of the single cutting teeth** **of a router** Angaben / Data in [mm]
Spitzenwinkel / Point Angle **Typ / Type 802/803/804/806/809**	**α**	**±3** Angaben / Data in [°]

Typ / Type 802/803/804/806/809:



Typ / Type 850:



626

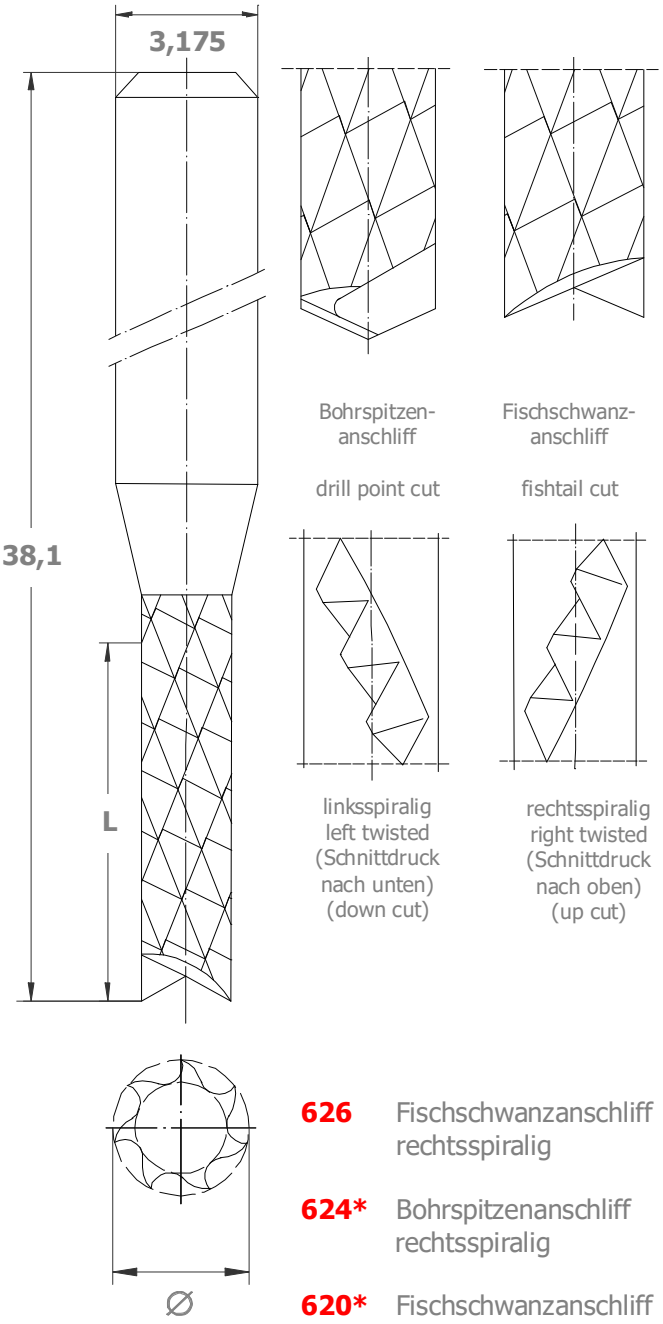
624
620

Fräser mit Diamantverzahnung
Anwendungen:

- **Standardfräser für Innen- und Außenkonturen**
- **alle Basismaterialien aus Glasgewebe**

Router with diamond-patterned teeth
Applications:

- **standard router for inner and outer contours**
- **glass-epoxy based materials**



626			
Ø [mm]	L [mm] 7,0	8,0	10,0
1,0	x		
1,1	x		
1,2	x		
1,3	x		
1,4	x		
1,5		x	
1,6		x	
1,7		x	
1,8		x	
1,9		x	
2,0		x	x
2,1		x	
2,2		x	
2,3		x	
2,4		x	x
2,5		x	
3,0			x*
3,175			x*

626	Fischschwanzanschliff rechtsspiralig	fishtail cut up cut (right twisted)
624*	Bohrspitzenanschliff rechtsspiralig	drill point cut up cut (right twisted)
620*	Fischschwanzanschliff linksspiralig * auf Anfrage	fishtail cut down cut (left twisted) * on request

726

724

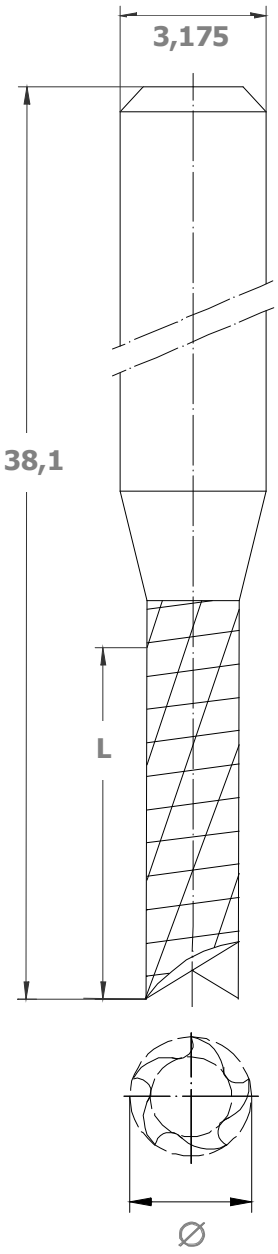
720

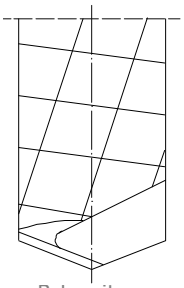
Fräser mit Spiralverzahnung
Anwendungen/Vorteile:

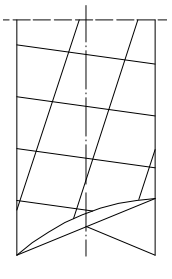
- **Standardfräser für Innen- und Außenkonturen**
- **alle Basismaterialien aus Glasgewebe**
- **sehr guter Spantransport und sehr gute Oberflächenqualität**

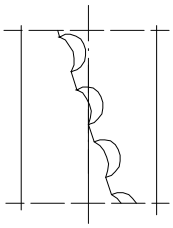
Router with spiral-patterned teeth
Applications/Advantages:

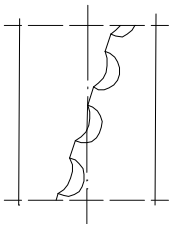
- **standard router for inner and outer contours**
- **all kind of glass-epoxy based materials**
- **excellent chip transport and surface finish**











726 Fischschwanzanschliff
rechtsspiralig
fishtail cut
up cut (right twisted)

724* Bohrspitzenanschliff
rechtsspiralig
drill point cut
up cut (right twisted)

720* Fischschwanzanschliff
linksspiralig
fishtail cut
down cut (left twisted)

726						
Ø [mm]	L [mm] 3,0	3,5	5,0	7,0	8,5	9,0
0,5	x					
0,6	x					
0,7		x				
0,8			x			
0,9			x			
1,0				x	x*	
1,1				x	x*	
1,2				x	x*	
1,3				x	x*	
1,4				x	x*	
1,5					x	
1,6					x	
1,7					x	
1,8					x	
1,9					x	
2,0						x
2,1						x*
2,2						x*
2,3						x*
2,4						x
2,5						x
3,0						x
3,175						x

* auf Anfrage * on request

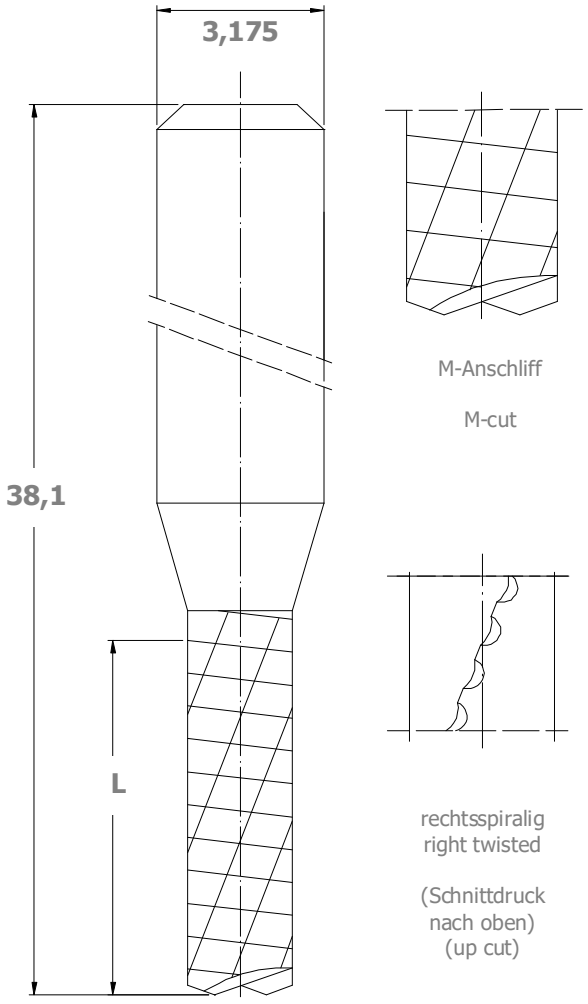
790

Diamantbeschichteter Fräser aus Vollhartmetall mit Spiralverzahnung
Anwendungen/Vorteile:

- **Standardfräser für Innen- und Außenkonturen**
- **abrasive Basismaterialien**
- **guter Spantransport und sehr gute Oberflächenqualität**
- **engste Frästoleranzen**

Diamond coated router made of solid carbide with spiral-patterned teeth
Applications/Advantages:

- **standard router for inner and outer contours**
- **abrasive base materials**
- **good chip transport and excellent surface quality**
- **tightest routing tolerances**

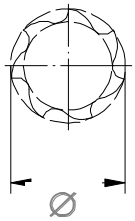


M-Anschliff

M-cut

rechtsspiralig
right twisted

(Schnittdruck
nach oben)
(up cut)



790 M-Anschliff
rechtsspiralig

M-cut
up cut (right twisted)

790							
Ø [mm]	L [mm] 3,5	4,0	5,0	6,5	7,0	8,5	9,0
0,8	x*						
0,9		x*					
1,0		x*	x	x*			
1,1				x*			
1,2		x*			x*		
1,3					x*		
1,4		x*			x*		
1,5		x*				x*	
1,6						x	
1,7						x*	
1,8		x*				x*	
1,9						x*	
2,0		x*					x
2,1							x*
2,2							x*
2,3							x*
2,4							x
2,5							x*
3,0							x
3,175							x*

* auf Anfrage * on request

802

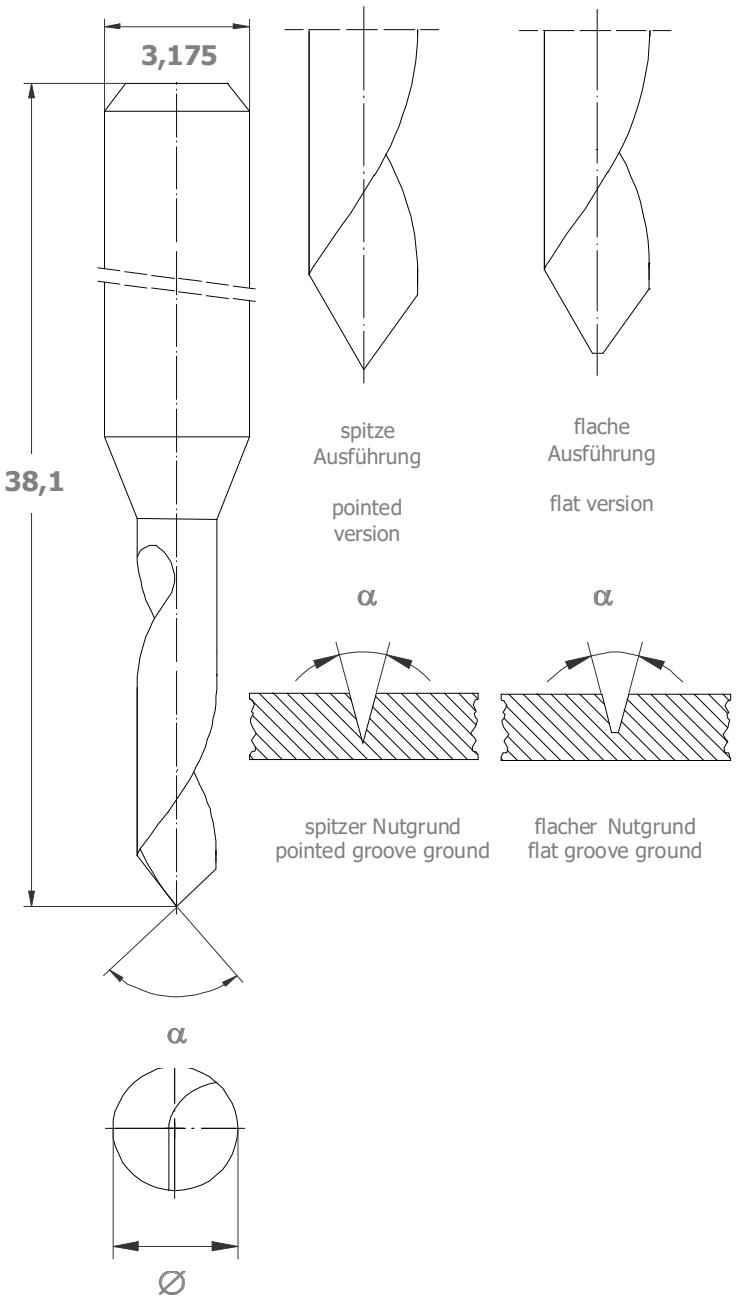
801
803
804
806
809

Frässtichel mit einer Spiralnut
Anwendungen:

- **Ritzen und Anfasen von Leiterplatten**
- **Fräsen von Isolationsabständen**
- **Ritzen von Bruchkanten**

V-groove cutter with one spiral-twisted flute
Applications:

- **chamfering of circuit boards**
- **routing of dielectric spacing**
- **scribing of break-out edges**



∅ [mm]	α 22°	30°	45°	60°	90°
2,0		x	x		
2,4				x	
3,175	x				x
Standard	801	802 803	804	806	809

Bemerkung: andere Spitzenwinkel / Durchmesser auf Anfrage
Remark: other point angles / diameters on request

801 22° spitze Ausführung
22° pointed version

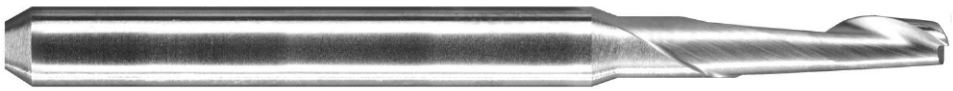
802 30 ° flache Ausführung
30 ° flat version

803 30 ° spitze Ausführung
30 ° pointed version

804 45 ° spitze Ausführung
45 ° pointed version

806 60 ° spitze Ausführung
60 ° pointed version

809 90 ° spitze Ausführung
90 ° pointed version



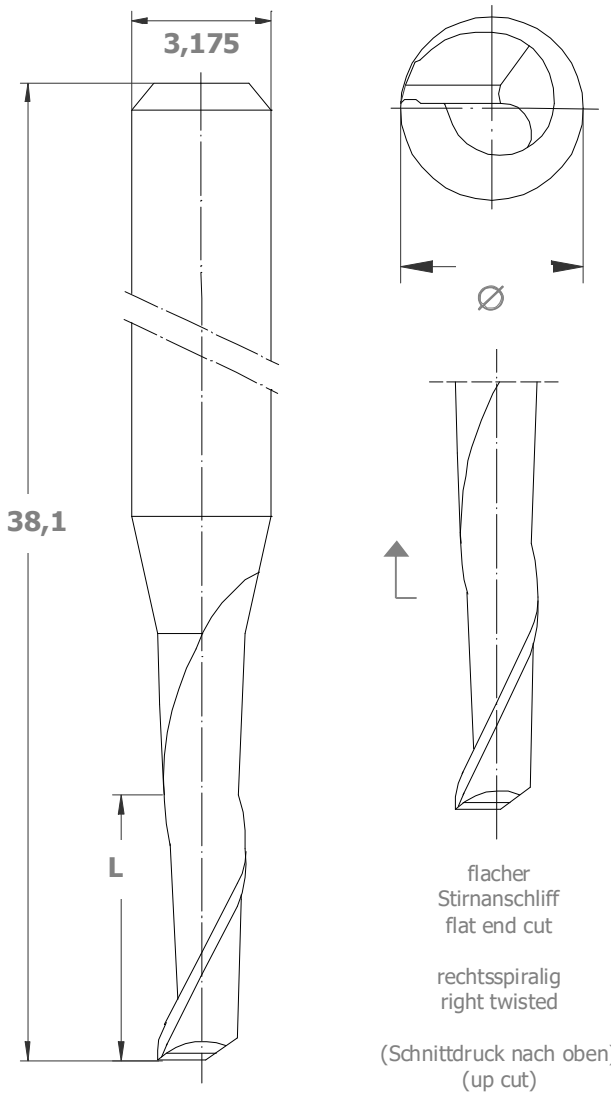
817

Fräser mit einer Hauptschneide
Anwendungen/Vorteile:

- **für Tiefenfräsen, Innenkonturen, Schlitze**
- **weiche Kunststoffe, Folien, PE, PTFE, PMMA, Polyimid**
- **Prepregs und FR4**
- **Flex-Anwendungen**
- **beste Oberflächen- und Kantenqualität**

1-Flute router
Application/Advantages:

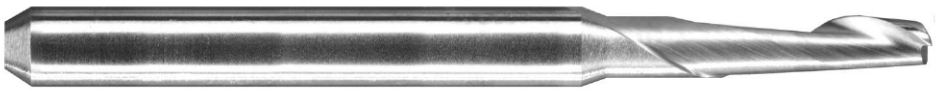
- **for depth routing, inner contours, slots**
- **soft plastics, foils, PE, PTFE, PMMA, polyimide**
- **thin prepregs and FR4**
- **Flex-applications**
- **best surface and edge quality**



817					
Ø [mm]	L [mm] 3,0	4,0	5,0	8,0	9,0
1,0	x				
1,1	x*				
1,2		x			
1,3		x*			
1,4		x*			
1,5		x*			
1,6			x		
1,7			x*		
1,8			x*		
1,9			x*		
2,0				x	
2,4				x	
3,0					x
3,175					x*

* auf Anfrage * on request

817 flacher Stirnanschliff
rechtsspiralig (Schnittdruck nach oben)
flat end cut
up cut (right twisted)



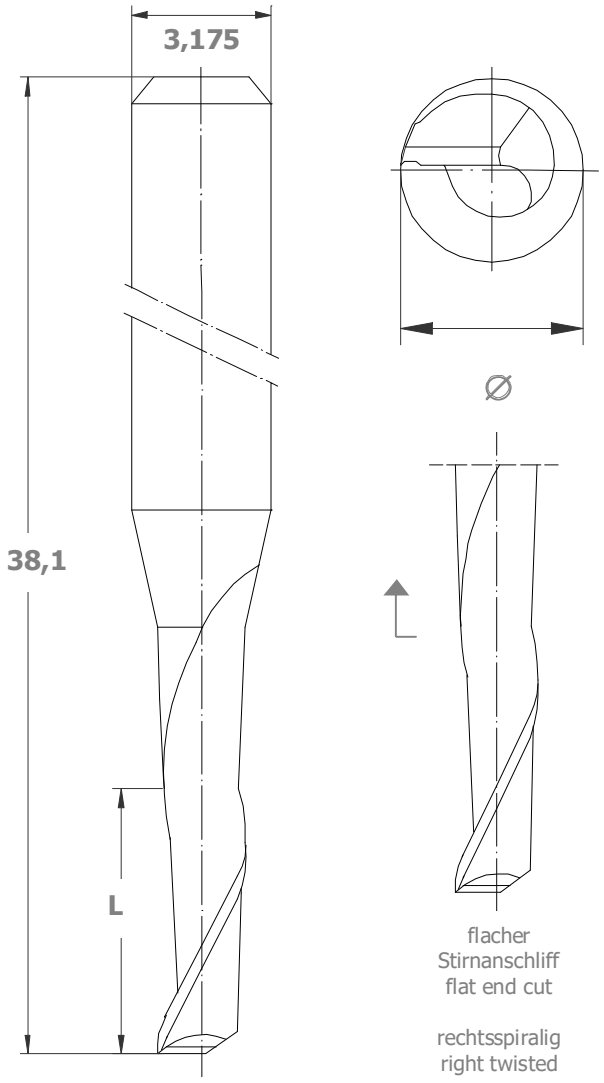
818

Fräser mit einer Hauptschneide
Anwendungen/Vorteile:

- **für Tiefenfräsen, Innenkonturen, Schlitze**
- **weiche Kunststoffe, Folien**
- **Al, Cu, Messing, Metalle**
- **beste Oberflächen- und Kantenqualität**

1-Flute router
Application/Advantages:

- **for depth routing, inner contours, slots**
- **soft plastics, foils**
- **Al, Cu, brass, metals**
- **best surface and edge quality**



818 flacher Stirnanschliff
rechtsspiralig (Schnittdruck nach oben)
flat end cut
up cut (right twisted)

818						
∅ [mm]	L [mm] 1,5	3,0	4,0	5,0	8,0	9,0
0,4	x					
0,5		x				
0,6		x				
0,7		x				
0,8		x				
0,9		x				
1,0		x				
1,1		x*				
1,2			x			
1,3			x*			
1,4			x			
1,5			x			
1,6				x		
1,7				x*		
1,8				x*		
1,9				x*		
2,0					x	
2,4					x	
3,0						x
3,175						x*

* auf Anfrage * on request

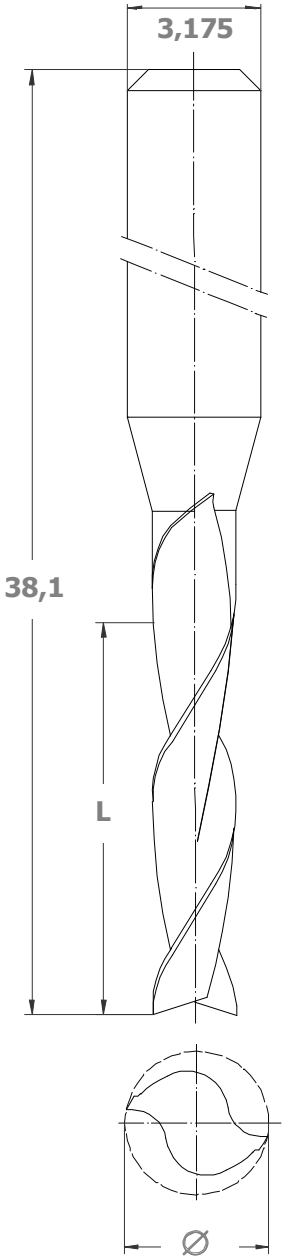
826 828

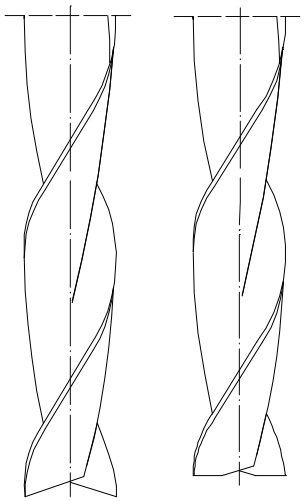
Fräser mit 2 Hauptschneiden
Anwendungen/Vorteile:

- **für Tiefenfräsungen Typ 828**
- **Innenkonturen/Schlitze mit sehr hohen Qualitätsanforderungen**
- **Cu, Messing und Metalle**
- **beste Oberflächen- und Kantenqualität**
- **sehr guter Spantransport**

2-Flute router
Applications/Advantages:

- **for depth routing type 828**
- **inner contours/slots with high quality demands**
- **routing Cu, brass and metals**
- **best surface and edge quality**
- **excellent chip transport**





Fischschwanz-anschliff
fishtail cut

flacher Stirnanschliff
flat end cut

rechtsspiralig
right twisted

(Schnittdruck nach oben)
(up cut)

826
Fischschwanzanschliff
rechtsspiralig
fishtail cut
up cut (right twisted)

828
flacher Stirnanschliff
rechtsspiralig
flat end cut
up cut (right twisted)

* auf Anfrage
* on request

826 828								
Ø [mm]	L [mm]							
	0,7	1,0	1,5	3,0	5,0	6,0	8,0	10,0
0,20	x*							
0,25		x*						
0,30		x*						
0,40			x*					
0,50				x				
0,60				x				
0,70				x				
0,80					x			
0,90					x			
1,00					x			
1,10					x			
1,20					x			
1,30					x			
1,40					x			
1,50						x		
1,60						x		
1,70						x		
1,80						x		
1,90						x		
2,00							x	
2,10							x	
2,20							x	
2,30							x	
2,40							x	
2,50							x	
3,00								x
3,175								x

827

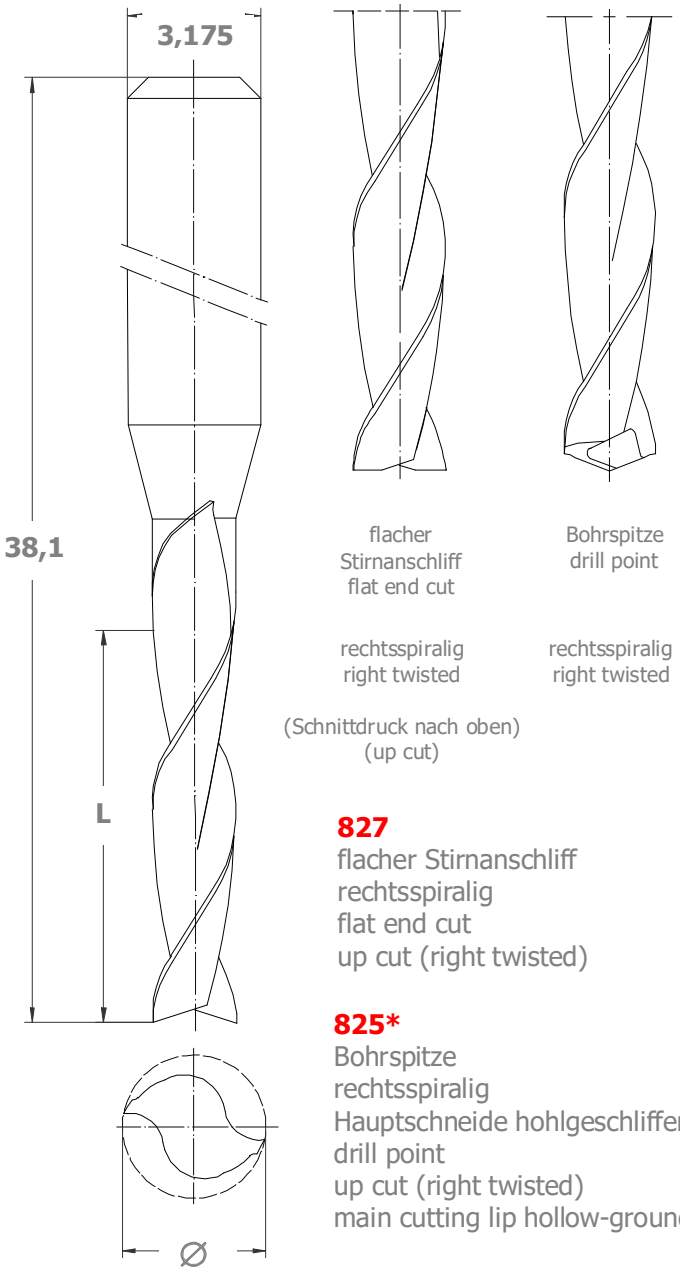
825

Fräser mit 2 Hauptschneiden
Anwendungen/Vorteile:

- für die Leiterplatte
  - Tiefenfräsungen Typ 828
  - Innenkonturen/Schlitze mit sehr hohen Qualitätsanforderungen
  - weiche Kunststoffe, Folien, PE, PTFE, PMMA und Polyimid
  - Prepregs und FR4
  - Flex-Anwendungen
  - sehr guter Spantransport

2-Flute router
Applications/Advantages:

- for PCB
  - depth routing type 828
  - inner contours/slots with high quality demands
  - routing plastics, foils, PE, PTFE, PMMA and polyimide
  - prepregs and FR4
  - flex-applications
  - excellent chip transport



flacher Stirnanschliff
flat end cut

rechtsspiralig
right twisted

Bohrspitze
drill point

rechtsspiralig
right twisted

(Schnittdruck nach oben)
(up cut)

827
flacher Stirnanschliff
rechtsspiralig
flat end cut
up cut (right twisted)

825*
Bohrspitze
rechtsspiralig
Hauptschneide hohlgeschliffen
drill point
up cut (right twisted)
main cutting lip hollow-grounded

827					
Ø [mm]	L [mm] 3,0	5,0	6,0	8,0	10,0
0,6	x*				
0,7	x*				
0,8		x*			
0,9		x*			
1,0		x			
1,1		x*			
1,2		x			
1,3		x*			
1,4		x*			
1,5			x*		
1,6			x		
1,7			x*		
1,8			x*		
1,9			x*		
2,0				x	
2,1				x*	
2,2				x*	
2,3				x*	
2,4				x	
2,5				x*	
3,0					x
3,175					x*

* auf Anfrage * on request

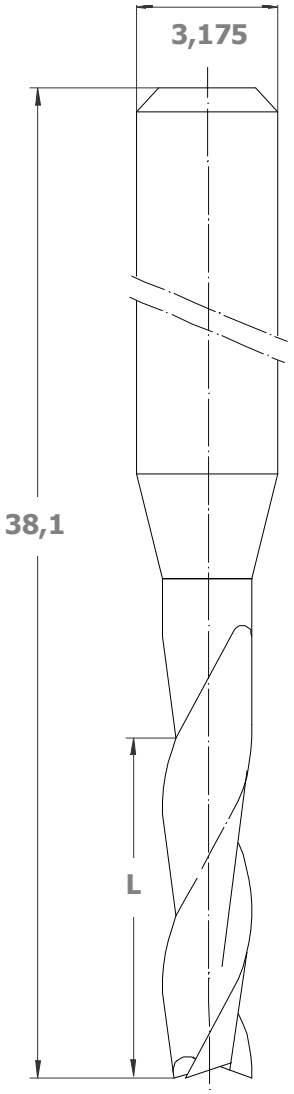
836

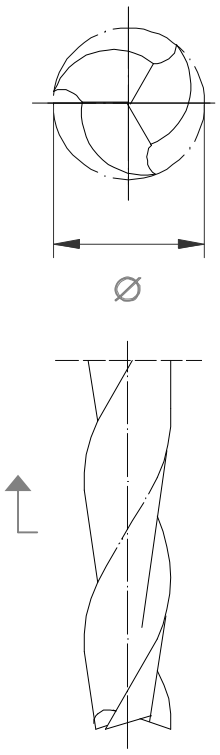
Fräser mit 3 Hauptschneiden
Anwendungen:

- **für Innenkonturen und metallisierte Schlitze**
- **Fräsen von Metalloberflächen**
- **weiche Kunststoffe, Folien, PE, PTFE, PMMA, Polyimid**
- **Prepregs und FR4**
- **Flex-Anwendungen**
- **beste Oberflächen- und Kantenqualität**
- **guter Spantransport**

3-Flute router
Applications:

- **routing inner contours and slots**
- **routing metal surfaces**
- **soft plastics, foils, PE, PTFE, PMMA, polyimide**
- **thin prepregs and FR4**
- **flex-applications**
- **best surface and edge quality**
- **good chip transport**





Fischschwanzanschliff
fishtail cut

rechtsspiralig
right twisted

(Schnittdruck nach oben)
(up cut)

836 Fischschwanzanschliff
rechtsspiralig
fishtail cut
up cut (right twisted)

836			
Ø [mm]	L [mm] 5,0	7,0	9,0
1,0	x*		
1,1	x*		
1,2	x*		
1,3	x*		
1,4	x*		
1,5		x*	
1,6		x*	
1,7		x*	
1,8		x*	
1,9		x*	
2,0			x*
2,1			x*
2,2			x*
2,3			x*
2,4			x*
2,5			x*
3,0			x*
3,175			x*

* auf Anfrage * on request

850

Kegelsenker mit 5 Schneiden

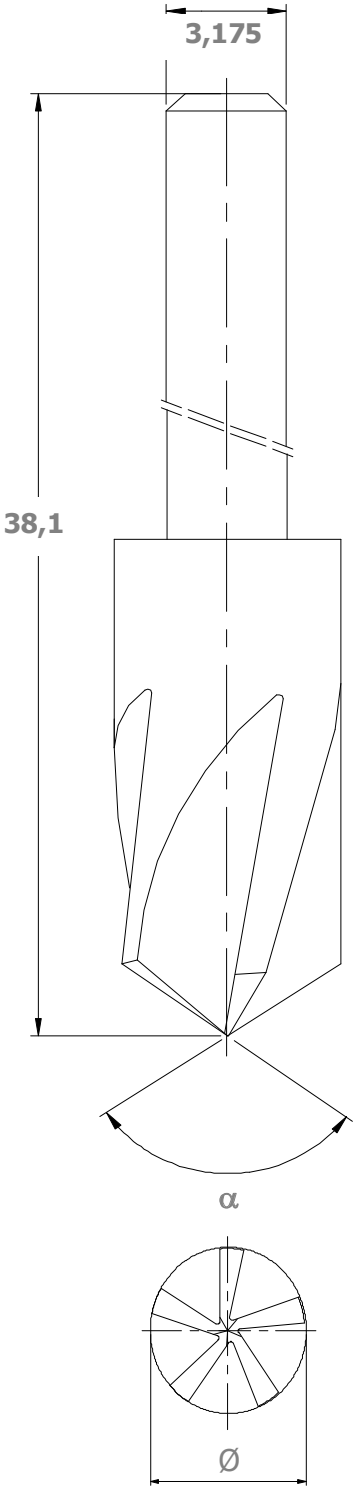
Anwendungen:

- **Senken von Bohrungen**
- **Anfasen von Leiterplatten**

Countersink with 5 flutes

Applications:

- **countersinking of drill holes**
- **chamfering of circuit boards**



850			
Ø [mm]	α 90°	120°	140°
6,0	x	x	x

Bemerkung:
Andere Spitzenwinkel / Durchmesser auf Anfrage.
Remark:
Other point angles / diameters on request.

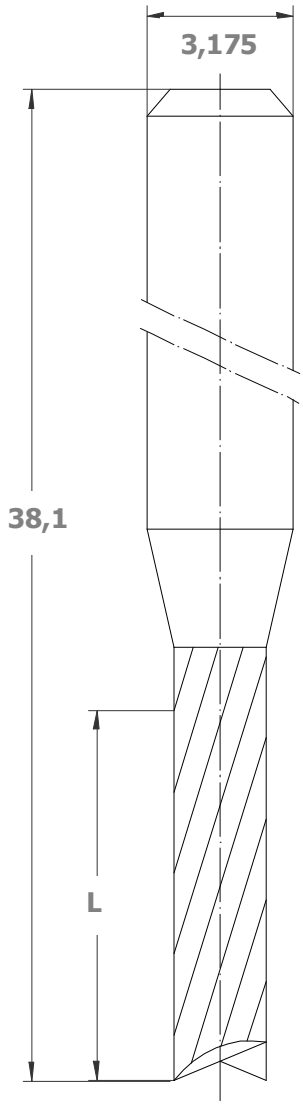
876

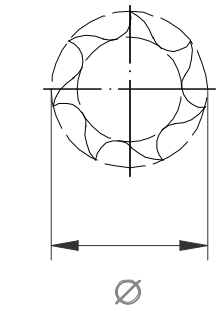
Schlichtfräser
Anwendung:

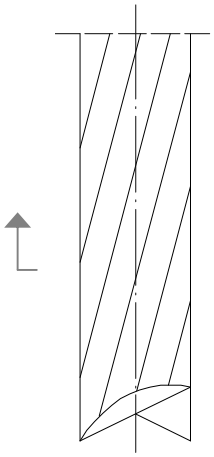
- **gratfreies Fräsen von Galvanoanbindungen (Goldfingers) und Metalloberflächen**

Contour finishing router
Application:

- **burr-free routing of metal surfaces (goldfingers) and metal composite laminates**







Fischschwanzanschliff
fishtail cut

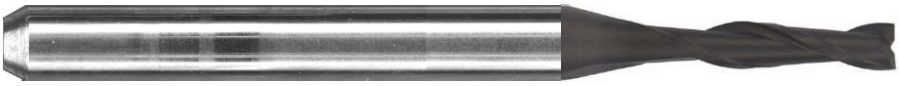
rechtsspiralig
right twisted

(Schnittdruck nach oben)
(up cut)

876	
Ø [mm]	L [mm] 7,0
1,6	x*
2,0	x*
2,4	x*

Bemerkung:
Andere Durchmesser auf Anfrage.
Remark:
Other diameters on request.

876 Fischschwanzanschliff
rechtsspiralig
fishtail cut
up cut (right twisted)



891

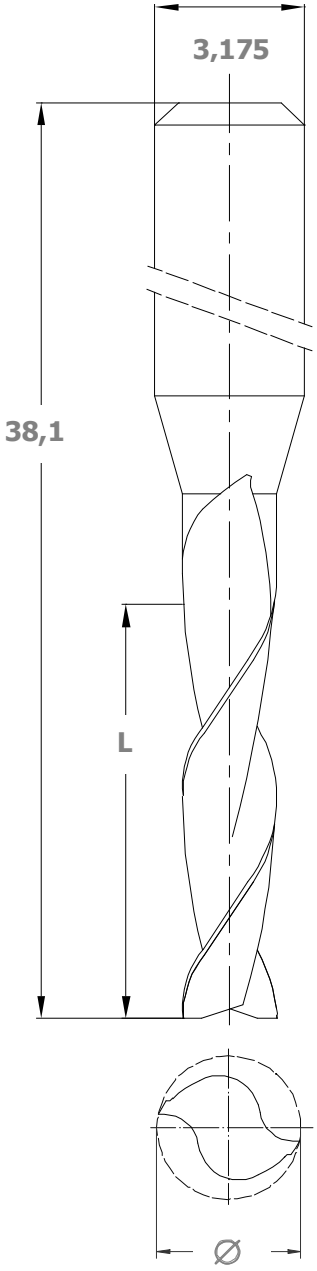
Diamantbeschichteter Fräser aus Vollhartmetall mit 2 Hauptschneiden
Anwendungen/Vorteile:

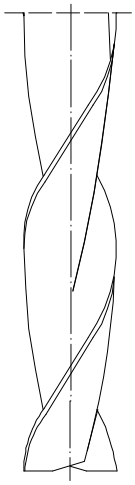
- **Innenkonturen/Schlitze mit sehr hohen Qualitätsanforderungen**
- **Geeignet zum Fräsen von Aluminium (trocken), Kupfer und GFK mit keramischen Füllstoffen**
- **sehr guter Spantransport**
- **Tiefenfräsungen möglich**

Diamond coated 2-flute router made of solid carbide

Applications/Advantages:

- **inner contours/slots with high quality demands**
- **routing aluminium (dry), copper and GRP with ceramic fillers**
- **excellent chip transport**
- **depth routing possible**





flacher Stirnanschliff
flat end cut

rechtsspiralig
right twisted

(Schnittdruck nach oben)
(up cut)

891
flacher Stirnanschliff
rechtsspiralig
flat end cut
up cut (right twisted)

891			
Ø [mm]	L [mm] 3,0	4,0	6,0
0,9		x*	
1,0	x	x*	
1,1	x*		
1,2	x*	x*	
1,3	x*		
1,4	x*	x*	
1,5		x*	x
1,6			x*
1,7			x*
1,8		x*	x*
1,9			x*
2,0		x*	x
2,1			x*
2,2			x*
2,3			x*
2,4			x
2,5			x*
3,0			x
3,175			x*

* auf Anfrage * on request

Parameter Recommendation for Microdrill Dia. 0.10 - 0.50 mm in FR4

Parameter for [1]: **FR4 ML 4 - 8 layer**

Ø	chip-load	Different Spindle Types [1]								retract feed
		180000 max.		200000 max.		250000 max.		300000 max.		
(mm)	(µm/1)	spindle speed (rpm)	feed rate (m/min)	spindle speed (rpm)	feed rate (m/min)	spindle speed (rpm)	feed rate (m/min)	spindle speed (rpm)	feed rate (m/min)	(m/min)
0,10	5	160000	0,8	180000	0,9	250000	1,2	300000	1,4	2,0
0,105	5	160000	0,8	180000	0,9	250000	1,2	300000	1,4	2,0
0,11	6	160000	0,9	180000	1,0	250000	1,4	300000	1,7	2,0
0,12	7	160000	1,2	180000	1,3	250000	1,8	300000	2,2	2,0
0,15	8	160000	1,3	180000	1,4	250000	2,0	300000	2,4	3,0
0,20	11	160000	1,8	180000	2,0	239000	2,7	239000	2,7	4,0
0,25	15	160000	2,4	180000	2,7	191000	2,9	191000	2,9	5,0
0,30	18	160000	2,9	160000	2,9	160000	2,9	160000	2,9	6,0
0,35	21	137000	2,8	137000	2,8	137000	2,8	137000	2,8	7,0
0,40	23	120000	2,8	120000	2,8	120000	2,8	120000	2,8	8,0
0,45	26	107000	2,8	107000	2,8	107000	2,8	107000	2,8	9,0
0,50	30	96000	2,8	96000	2,8	96000	2,8	96000	2,8	10,0

[1] Other materials and spindle speeds on request

Parameter Recommendation for Drills

Material [1]:	**FR 4 ≤ 6 layers**	**Cutting Speed** v_s=	**150 [m/min]**
Spindle Type:	**Air Bearing**	**Spindle Speed [1]** n_{max}=	**125000 [rpm]**

Diameter = D [mm] Spindle Speed = n [rpm]
Chip Load = f [µm/1] Retract Feed = R [m/min] Infeed = F [m/min]

D	f	F	n	R	D	f	F	n	R
0.10	6	0.8	125000	2.0	2.30	90	1.9	21000	25.0
0.15	10	1.3	125000	3.0	2.35	90	1.8	20000	25.0
0.20	14	1.8	125000	4.0	2.40	90	1.8	20000	25.0
0.25	19	2.4	125000	5.0	2.45	90	1.8	20000	25.0
0.30	23	2.9	125000	6.0	2.50	90	1.8	20000	25.0
0.35	26	3.3	125000	7.0	2.55	90	1.8	20000	25.0
0.40	29	3.5	119000	8.0	2.60	90	1.8	20000	25.0
0.45	33	3.5	106000	9.0	2.65	90	1.8	20000	25.0
0.50	37	3.5	95000	10.0	2.70	90	1.8	20000	25.0
0.55	42	3.7	87000	15.0	2.75	90	1.8	20000	25.0
0.60	46	3.7	80000	20.0	2.80	90	1.8	20000	25.0
0.65	50	3.7	73000	25.0	2.85	90	1.8	20000	25.0
0.70	55	3.7	68000	25.0	2.90	90	1.8	20000	25.0
0.75	60	3.8	64000	25.0	2.95	90	1.8	20000	25.0
0.80	65	3.9	60000	25.0	3.00	90	1.8	20000	25.0
0.85	70	3.9	56000	25.0	3.05	90	1.8	20000	25.0
0.90	75	4.0	53000	25.0	3.10	90	1.8	20000	25.0
0.95	80	4.0	50000	25.0	3.15	90	1.8	20000	25.0
1.00	85	4.1	48000	25.0	3.175	90	1.8	20000	25.0
1.05	90	4.1	45000	25.0	3.20	46	0.9	20000	25.0
1.10	90	3.9	43000	25.0	3.30	46	0.9	20000	25.0
1.15	90	3.8	42000	25.0	3.40	46	0.9	20000	25.0
1.20	90	3.6	40000	25.0	3.50	46	0.9	20000	25.0
1.25	90	3.4	38000	25.0	3.60	46	0.9	20000	25.0
1.30	90	3.3	37000	25.0	3.70	46	0.9	20000	25.0
1.35	90	3.2	35000	25.0	3.80	46	0.9	20000	25.0
1.40	90	3.1	34000	25.0	3.90	46	0.9	20000	25.0
1.45	90	3.0	33000	25.0	4.00	42	0.8	20000	25.0
1.50	90	2.9	32000	25.0	4.10	42	0.8	20000	25.0
1.55	90	2.8	31000	25.0	4.20	42	0.8	20000	25.0
1.60	90	2.7	30000	25.0	4.30	42	0.8	20000	25.0
1.65	90	2.6	29000	25.0	4.40	42	0.8	20000	25.0
1.70	90	2.5	28000	25.0	4.50	42	0.8	20000	25.0
1.75	90	2.4	27000	25.0	4.60	42	0.8	20000	25.0
1.80	90	2.4	27000	25.0	4.70	42	0.8	20000	25.0
1.85	90	2.3	26000	25.0	4.80	42	0.8	20000	25.0
1.90	90	2.3	25000	25.0	4.90	35	0.7	20000	25.0
1.95	90	2.2	24000	25.0	5.00	35	0.7	20000	25.0
2.00	90	2.2	24000	25.0	5.20	35	0.7	20000	25.0
2.05	90	2.1	23000	25.0	5.40	35	0.7	20000	25.0
2.10	90	2.1	23000	25.0	5.60	35	0.7	20000	25.0
2.15	90	2.0	22000	25.0	5.80	35	0.7	20000	25.0
2.20	90	2.0	22000	25.0	6.00	35	0.7	20000	25.0
2.25	90	1.9	21000	25.0	6.50	35	0.7	20000	25.0

[1] other materials and spindle speeds on request

Parameter Recommendation for Slot Drills

Material [1]: FR 4	**Cutting Speed v_s = 150 [m/min]**
Spindle Type: Air Bearing	**Spindle Speed [1] n_{max} = 125000 [rpm]**

Diameter = D [mm] Spindle Speed = n [rpm]
Chip Load = f [µm/1] Infeed = F [m/min] Retract Feed = R [m/min]

D	f	F	n	R	D	f	F	n	R
0.50	10	1.2	115000	10.0	1.90	76	1.9	25000	25.0
0.55	17	1.8	104000	10.0	1.95	78	1.9	24000	25.0
0.60	20	1.8	88000	15.0	2.00	80	1.9	24000	25.0
0.65	27	2.2	80000	25.0	2.05	80	1.8	23000	25.0
0.70	33	2.5	75000	25.0	2.10	80	1.8	23000	25.0
0.75	35	2.5	70000	25.0	2.15	80	1.8	22000	25.0
0.80	38	2.5	66000	25.0	2.20	80	1.8	22000	25.0
0.85	40	2.5	62000	25.0	2.25	80	1.7	21000	25.0
0.90	43	2.5	58000	25.0	2.30	80	1.7	21000	25.0
0.95	47	2.6	55000	25.0	2.35	80	1.6	20000	25.0
1.00	50	2.6	52000	25.0	2.40	80	1.6	20000	25.0
1.05	52	2.3	45000	25.0	2.45	80	1.6	20000	25.0
1.10	53	2.3	43000	25.0	2.50	80	1.6	20000	25.0
1.15	55	2.3	42000	25.0	2.55	70	1.4	20000	25.0
1.20	56	2.2	40000	25.0	2.60	70	1.4	20000	25.0
1.25	58	2.2	38000	25.0	2.65	70	1.4	20000	25.0
1.30	59	2.2	37000	25.0	2.70	70	1.4	20000	25.0
1.35	61	2.1	35000	25.0	2.75	70	1.4	20000	25.0
1.40	62	2.1	34000	25.0	2.80	70	1.4	20000	25.0
1.45	63	2.1	33000	25.0	2.85	70	1.4	20000	25.0
1.50	64	2.0	32000	25.0	2.90	70	1.4	20000	25.0
1.55	66	2.0	31000	25.0	2.95	70	1.4	20000	25.0
1.60	67	2.0	30000	25.0	3.00	60	1.2	20000	25.0
1.65	68	2.0	29000	25.0	3.05	60	1.2	20000	25.0
1.70	69	1.9	28000	25.0	3.10	60	1.2	20000	25.0
1.75	70	1.9	27000	25.0	3.15	60	1.2	20000	25.0
1.80	72	1.9	27000	25.0	3.175	60	1.2	20000	25.0
1.85	74	1.9	26000	25.0					

[1] other materials and spindle speeds on request

Parameter Recommendation for Routers

Material[1]: FR4

Cutting Speed: Type 626 = 190 m/min Type 726 = 220 m/min

Spindle type: Ball Bearing Spindle speed[1] $n_{max.}$= 60000 rpm

Tool type: 626 / 726

Diameter = **D** [mm]
Chip load = **f** [µm/1]
Infeed with / without pre-drilling = **F(Z)** [m/min]
max. stack height = **H** [mm]

Spindle speed = **n** [rpm]
Table feed = **F(XY)** [m/min]

D	f	F (XY)	n	n	F (Z) without	F (Z) with	H
			type 626	type 726	pre-drilling	pre-drilling	
[mm]	[µm/1]	[m/min]	rpm	rpm	[m/min]	[m/min]	[mm]
0.80	5	0.3		60000	0.2	0.5	3.5
0.90	6	0.4		60000	0.2	0.5	3.5
1.00	8	0.5	60000	60000	0.4	2.0	5.0
1.10	9	0.5	55000	60000	0.4	2.0	5.0
1.20	10	0.6	50000	58000	0.4	2.0	5.0
1.30	12	0.6	47000	54000	0.6	2.0	5.0
1.40	14	0.7	43000	50000	0.6	2.0	5.0
1.50	16	0.8	40000	47000	0.6	2.0	6.0
1.60	18	0.8	38000	44000	0.8	5.0	6.0
1.70	22	0.9	36000	41000	0.8	5.0	6.0
1.80	26	1.0	34000	39000	0.8	5.0	6.0
1.90	30	1.1	32000	37000	0.8	5.0	6.0
2.00	34	1.2	30000	35000	1.3	5.0	6.5
2.10	38	1.3	29000	33000	1.3	5.0	6.5
2.20	40	1.3	27000	32000	1.3	5.0	6.5
2.30	42	1.3	26000	30000	1.3	5.0	6.5
2.40	44	1.3	25000	29000	1.3	5.0	6.5
2.50	46	1.3	24000	28000	1.3	5.0	6.5
3.00	53	1.2	20000	23000	1.3	5.0	6.5
3.175	55	1.2	20000	22000	1.3	5.0	6.5

[1] other materials and spindle speeds on request

Formula for Cutting Parameters

Cutting Speed v_s:

$$v_s = \frac{n * D * \pi}{1000}$$

v_s = cutting speed [m/min]

n = spindle speed [rpm]
D = nominal diameter [mm]
π = 3,14

Chip load f:
(Feed per revolution)

$$f = \frac{F * 1000}{n}$$

f = chip load [mm/rev.]

F = feed rate [m/min]
n = spindle speed [1/min]

Conversion formula:

Feed rate F: $$F = \frac{f * n}{1000}$$

Spindle speed n: $$n = \frac{v_s}{D * \pi} * 1000$$

Example:

Given data: cutting speed v_s: 150 m/min
chip load f: 0,055 mm/rev
diameter D: 0,7 mm

$\Rightarrow$ spindle speed $n = \frac{150\ m/min}{(0{,}7\ mm * 3{,}14)} * 1000 = 68243\ rpm$

$\Rightarrow$ chosen spindle speed: **n = 68000 rpm**

$\Rightarrow$ feed rate $F = \frac{(0{,}055\ mm/rev * 68000\ rpm)}{1000} = 3{,}74\ m/min$

$\Rightarrow$ chosen feed rate: **F = 3,7 m/min**

Trouble Shooting

Trouble shooting when drilling printed circuit boards:

Problem	Possible Causes	Remedy
drill breakage	- chips jam in flute space	- use drills suitable for the specific cutting conditions (geometry), check extraction system/parameters
	- cutting pressure too high	- adapt feed rate
	- spindle run-out error	- check spindle run-out
	- dirty/defect collet	- clean/replace collet
	- drill deviation	- minimising of drill deviation
	- chipping on cutting edges	- ensure correct tool handling
inaccurate drill hole positioning (drill deviation)	- flute length too long	- adapt flute length
	- spindle run-out error	- check spindle run-out
	- dirty/defect collet	- clean/replace collet
	- pin hole inaccurate	- check pin hole
	- drill wear too high or chipping on cutting edges	- reduce hit counts/ no. of regrinding operations, check cutting conditions, check tool handling
poor surface quality of hole wall	- smear caused by inefficient chip removal	- improve chip removal by a) improved extraction system b) use tools with suitable geometry (spade type drills) c) modification of parameters
	- drill wear too high or chipping on cutting edges	- reduce hit counts/ no. of regrinding operations, check cutting conditions, check tool handling
	- board material insufficiently hardened	- check quality of the laminate (multilayer pressing conditions)
nail heading	- feed rate/retraction rate too high or too low	- adapt feed rate/retraction rate
	- wrong cutting parameters	- adapt cutting conditions to the laminate used
	- drill wear too high or chipping on cutting edges	- reduce hit count/ no. of regrinding operations, check cutting conditions, check tool handling
	- dwell time of drill at cusp too long	- reduce dwell time

Trouble Shooting

Problem	Possible Causes	Remedy
smear of resin	- excessive drilling temperatures	- increase feed rate, reduce cutting speed
	- laminate insufficiently hardened	- check laminate
	- drill wear too high or chipping on cutting edges	- reduce hit count/ no. of regrinding operations, check cutting conditions, check tool handling
	- insufficient de-smear process	- check de-smear process
burr on entry and/or exit side	- drill wear too high or chipping on cutting edges	- reduce hit count, check cutting conditions, check tool handling
	- feed rate/retraction rate too high	- reduce feed rate/retraction rate
	- entry/backup material too soft	- use harder entry/backup material
	- pressure foot power insufficient	- check pressure and correct operation of pressure foot
contamination on the entry and/or exit side	- wrong cutting parameters	- use recommended parameters
	- drill wear too high or chipping on cutting edges	- reduce hit count/ no. of regrinding operations, check cutting conditions, check tool handling
	- pressure foot power insufficient	- increase pressure foot power
	- entry/backup material too soft	- use harder entry/backup material
	- poor laminate bond	- check pressing procedure
deformation of inner layers	- chips jam in flute space	- use drills suitable for the specific cutting conditions (geometry), check extraction system/parameters
	- drill wear too high or chipping on cutting edges	- reduce hit count/no. of regrinding operations, check cutting conditions, check tool handling
	- poor laminate bond	- check pressing procedure
winding of chips on drill	- insufficient chip extraction	- clean and check extraction system, if necessary use more powerful extraction system
	- feed rate too low (chips get too long)	- increase feed rate