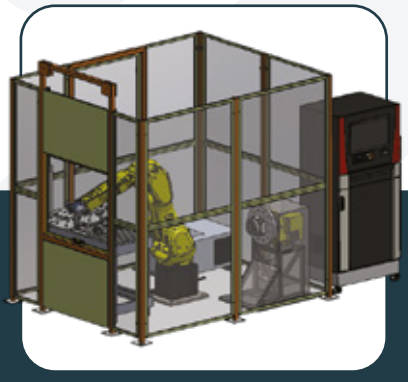
SAG·Tek

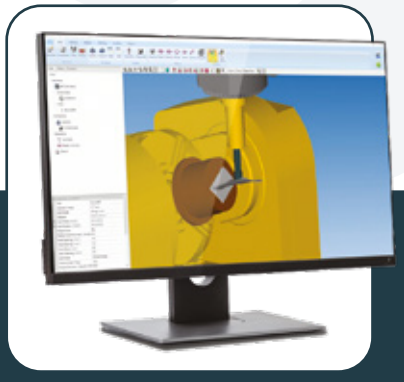
MICRON PERFECT POLISHING

From your existing CNC Machinery

SHAPE ADAPTIVE GRINDING (SAG)



ROBOT POLISHING CELL (RPC)



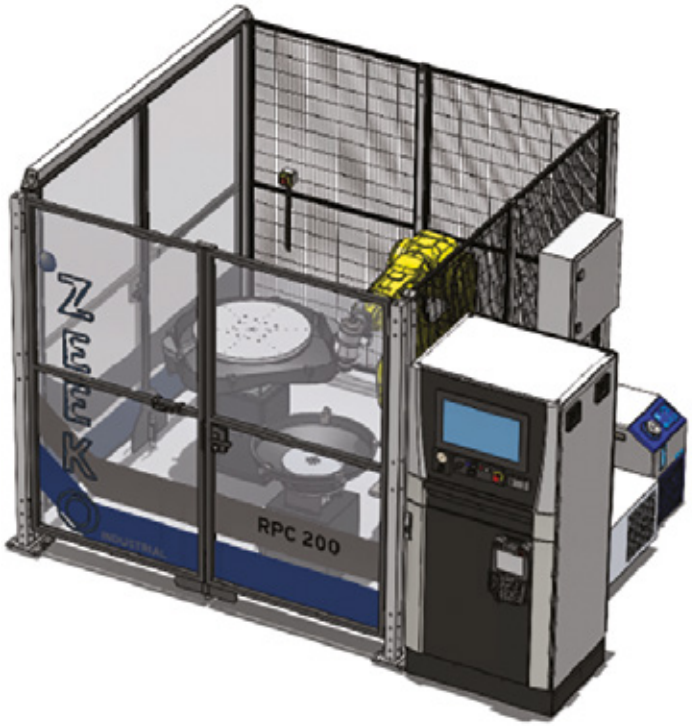
ZEPHYRCAM SOFTWARE

CONTENTS

1. INTRODUCTION

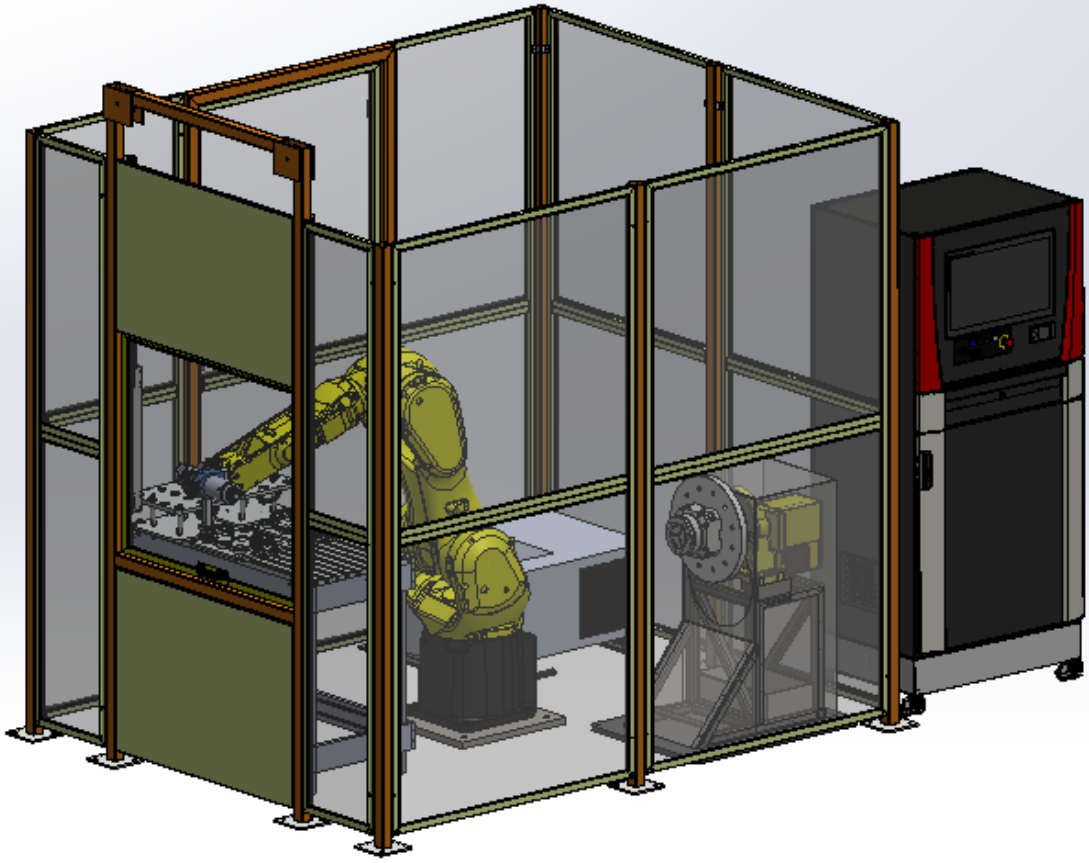
This booklet is a starters guide to the SAG process as developed by Zeeko Ltd. This guide will allow users to understand the benefits of the ZephyrCAM SAG process, as well how to run the process and which tools to use and when.

SAG Tools



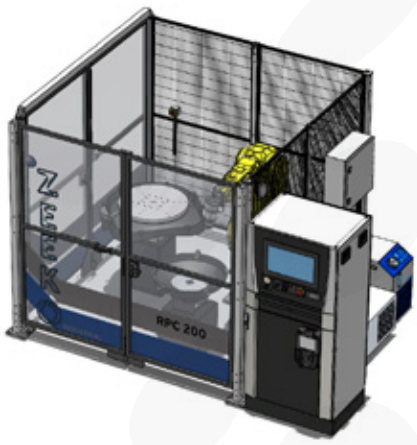
Robot Polishing Cell (RPC) - Industrial Version

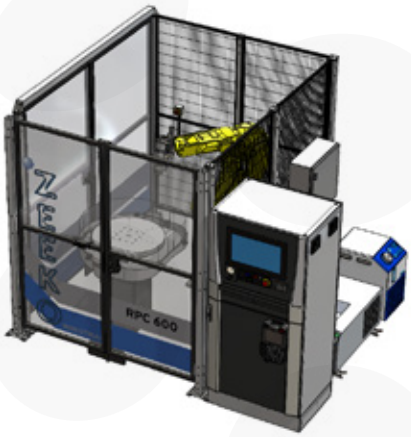
3. ROBOT POLISHING CELL (RPC) INDUSTRIAL RANGE

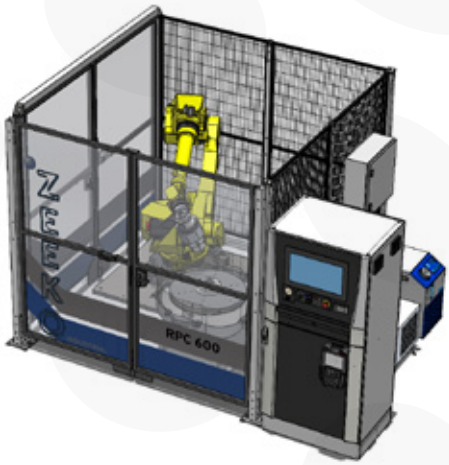


The RPC range is a modular finishing cell which can be put together to best suit your needs. The range offers varying levels of automation.

- Batch Loaded
- Machine Tending
- Inspection Station
- Cleaning Station
- Multiple work stations







4. WHAT IS THE SAG PROCESS?

The Shape Adaptive Grinding (SAG) process was developed by Zeeko between 2014 and the present as a novel process for precision grinding of freeform surfaces. The SAG process can achieve optical finish while maintaining high removal rates as compared to traditional CNC polishing.

A SAG tool can be described as a semi-elastic tool which is driven along the surface by a numerically controlled machine tool. The SAG-tool consists of a rigid metal stem, an elastic rubber layer which is coated with an abrasive layer. The single abrasive particles are held by the bond material.

Characteristic for SAG tools is the elastic tool body, which allows compliance with the freeform surface. The elastic body is covered with an abrasive cloth containing the rigid pellets. It is inside these pellets where the actual abrasive grains are bound.

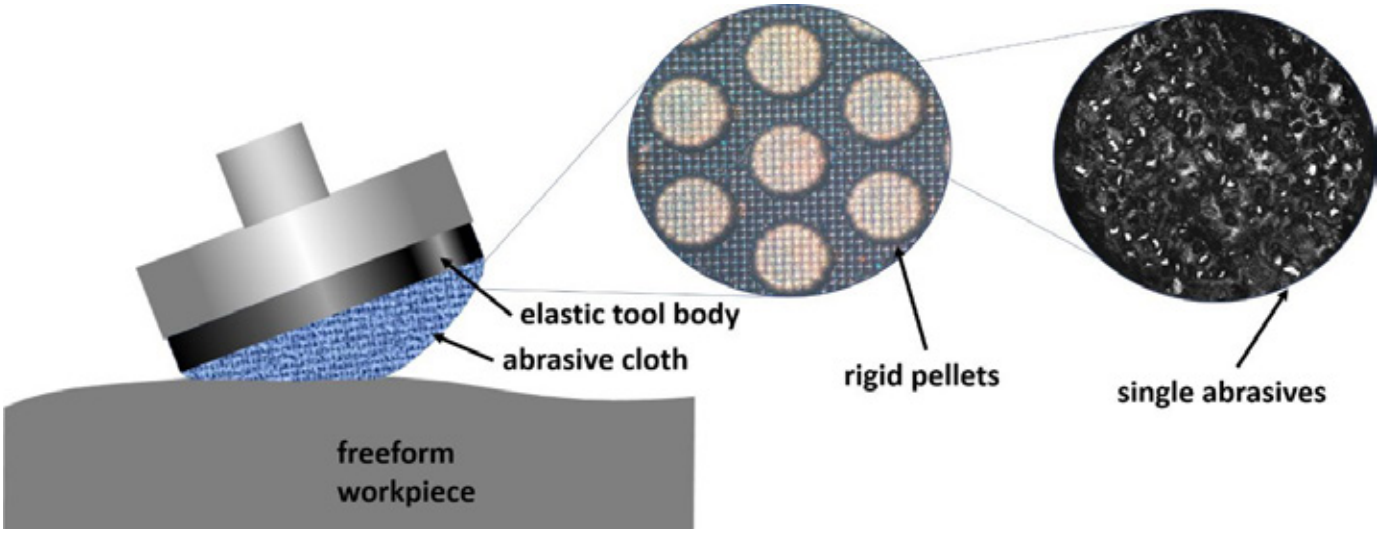


Figure 2-1 Example of the structure of a SAG tool

In Shape Adaptive Grinding the tool is pressed, while rotating, into the workpiece by a certain distance, which is called tool offset. It's this offset which creates the pressure that's needed for the grinding. Increasing the tool offset will also result in a larger contact area between tool and workpiece, which is called grinding spot.

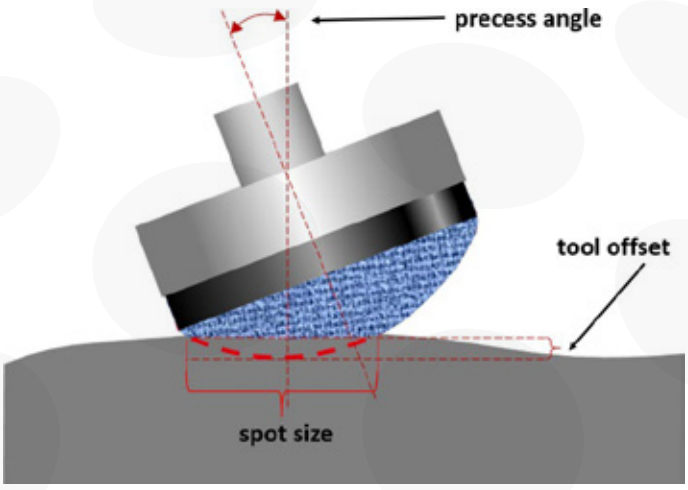


Figure 2-2 How the SAG tools are used

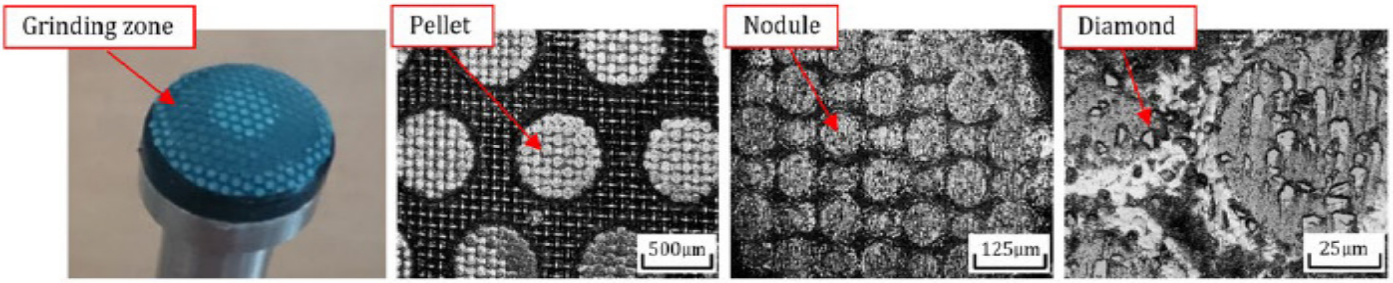
When using bonnet tools or ball-on-stick-tools, a precess angle can be applied. A precess angle is a change in the orientation of the spindle away from the surface normal. A greater precess angle leads to the contact spot being further away from the rotatory axes of the tool.

Choosing a larger tool leads to bigger spot sizes for the same offset. A larger spot size means grinding on a bigger area which increases the removal rate and decreases process time.
Shape adaptive grinding is a process that's conceptually situated between polishing and grinding. In the following we would like to highlight of some of these conceptual comparisons to provide a better understanding of the process.

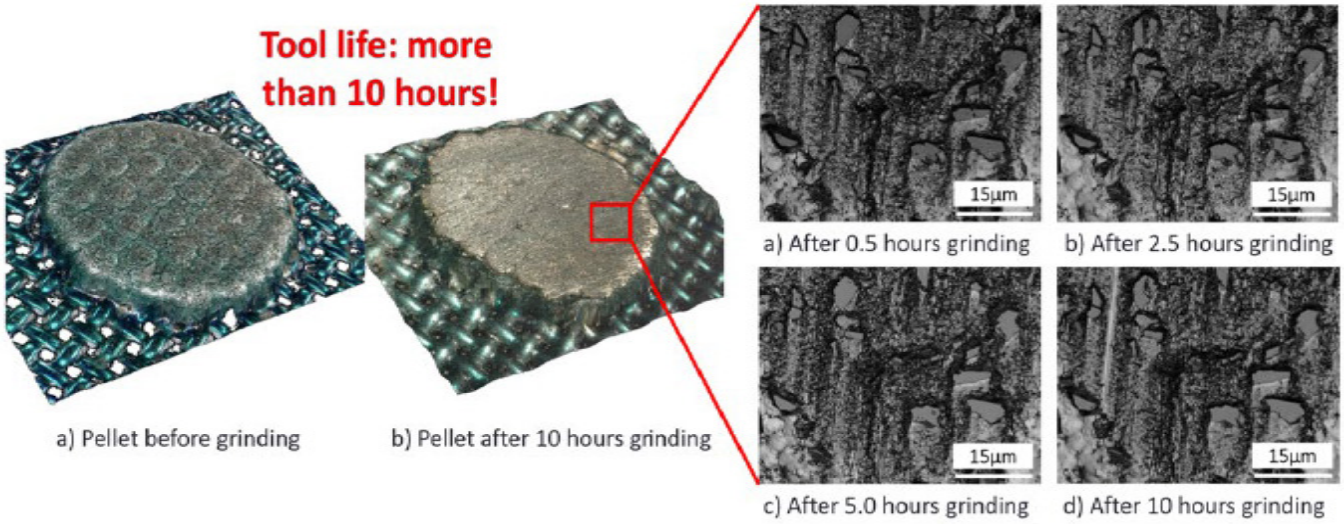
The most prominent difference between SAG and classical grinding is the contact between tool and workpiece. As the contact in classical grinding (with a grinding wheel) can be imagined much like a cut, as seen in milling or drilling processes, this contact takes place for SAG across an arc. The removal process takes place in this area, which we call the contact spot or grinding spot. This important conceptual difference implies that we need to look at certain parameters differently than what we are used to from the classical grinding process.

5. SAG TOOL STRUCTURE

• The structure of SAG tools: **Pellets** (0.5mm) > **Nodules** (80μm) > **Abrasives** (3-40μm).



• Even when grinding Silicon Carbide, the **number and shape of abrasives** remains stable for more than **10 hours**.



6. SAG CLOTHS

Zeeko is offers tools that come with two types of cloth resin bonded tool and nickel bonded tools.

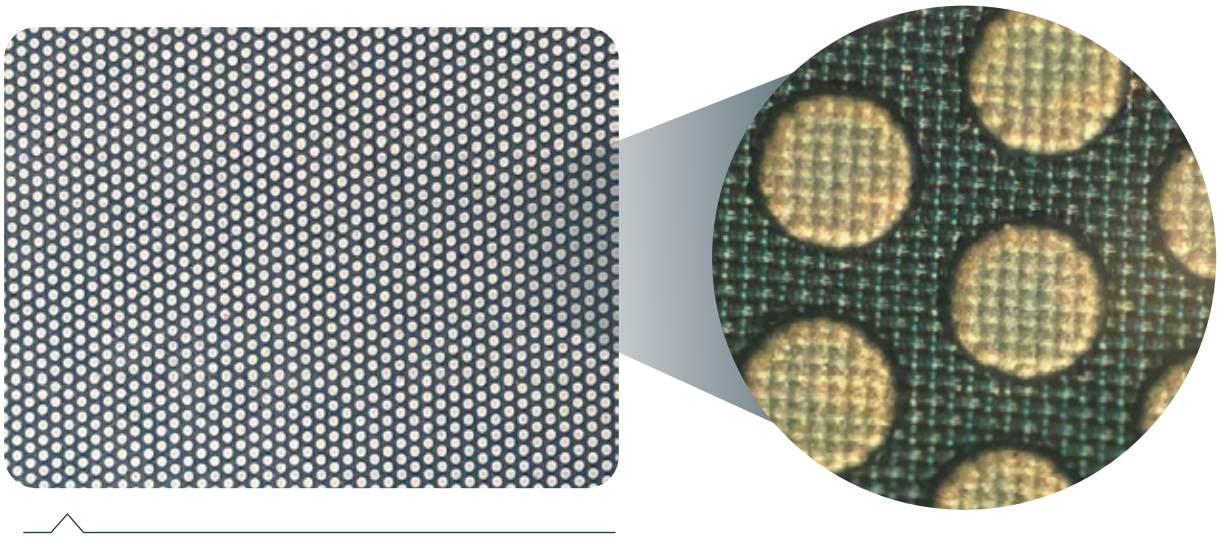


Figure 3-1 Nickel Bonded (NBD)

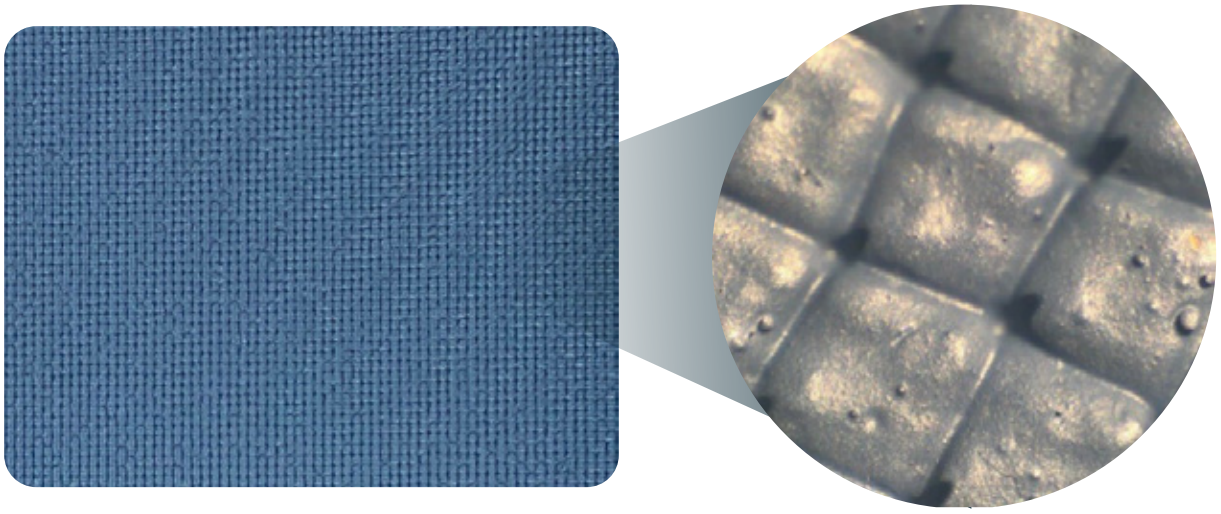
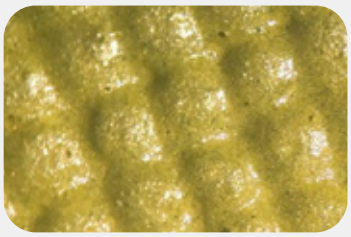
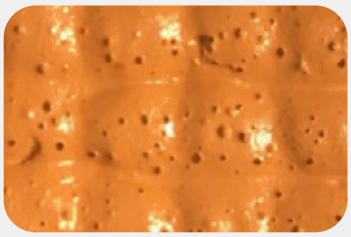
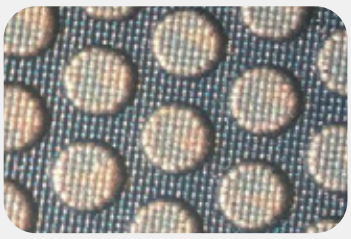


Figure 3-2 Resin Bonded (RBD)

PROPERTIES OF BOND MATERIALS	
NICKEL BOND	**RESIN BOND**
1. Higher wear resistance	1. Higher resistance against impacts
2. Higher thermal conductivity,	2. Higher rotational velocity
3. Higher material removal	3. Higher quality surface finish

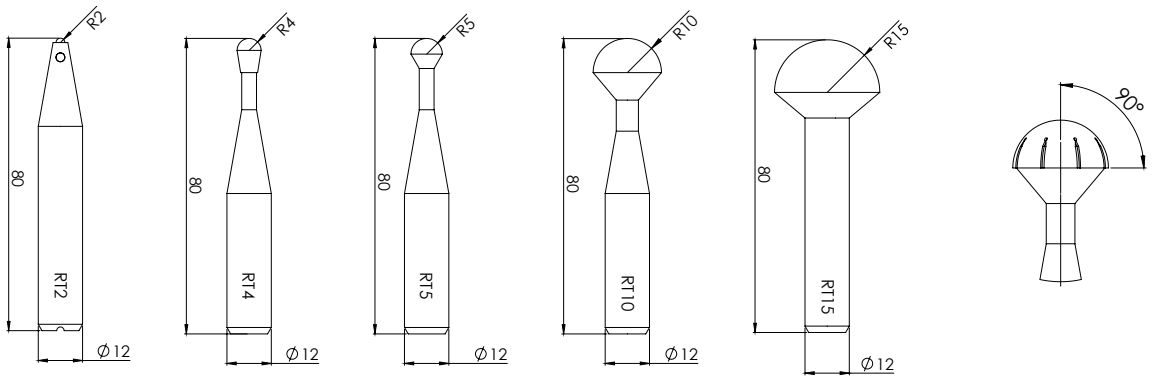
RESIN BONDED CLOTH			
GRIT SIZE	**COLOUR**	**IMAGE**	**DESCRIPTION**
40um	Yellow / Green		This cloth is used for removing machining marks left by former processes. It has a high removal rate at the cost of surface finish and potential crack induction for brittle materials.
9um	Blue		This cloth can achieve high removal rates. It is used for corrective polishing as well as for the removal of cracks induced by higher grit size tools. The resin bonded 9um cloth creates a slightly better surface than its nickel counterpart.
3um	Orange		This cloth is mainly used for finishing runs. It creates the best surface finish among the cloths listed. This comes at the cost of a low removal rate compared to the other cloths in this comparison.

NICKEL BONDED CLOTH			
GRIT SIZE	**COLOUR**	**IMAGE**	**DESCRIPTION**
40um	Yellow / Green		This cloth is used to remove machining marks of former processes. It has a high removal rate at the cost of surface finish and brittle removal.
9um	Blue		The 9um nickel bonded cloth has a slightly higher removal rate than is resin counterpart. This cloth is a good choice for form correction and cracks removal.

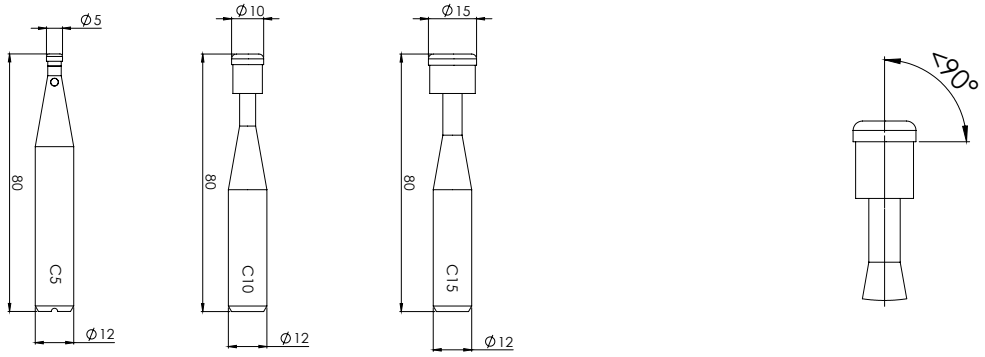
7. TOOL GEOMETRIES

There are multiple different tool geometries available in the ZephyrSAG tooling range. Each has a different working area as shown below. Any tool geometry can be paired with any SAG cloth.

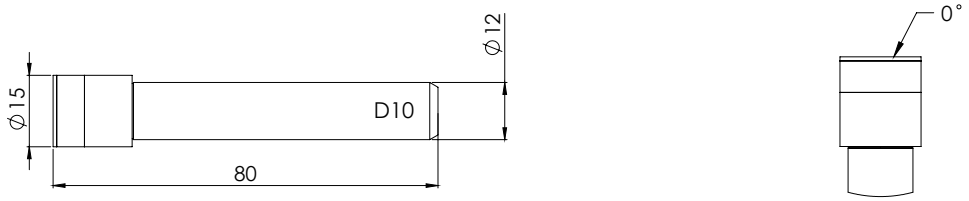
TEARDROP (RT)



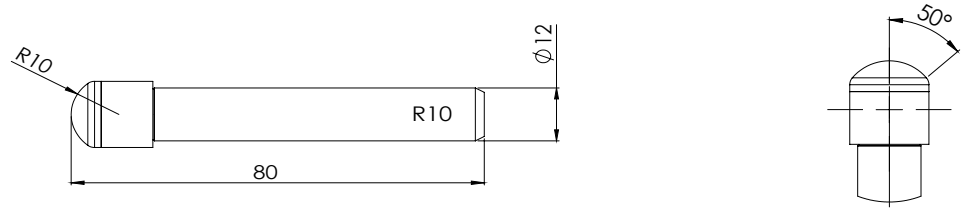
CAP (C)



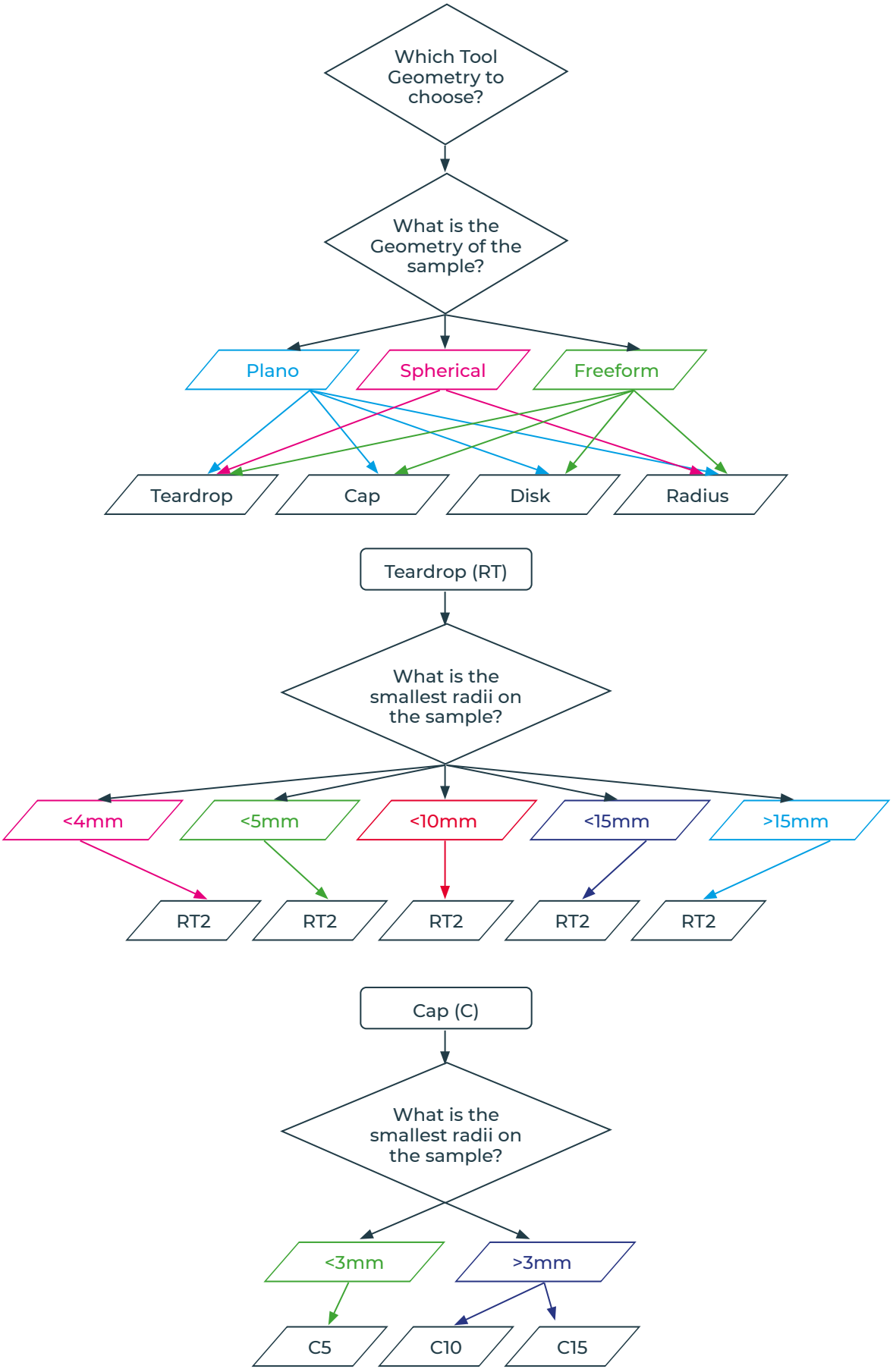
DISK (D)



RADIUS (R)



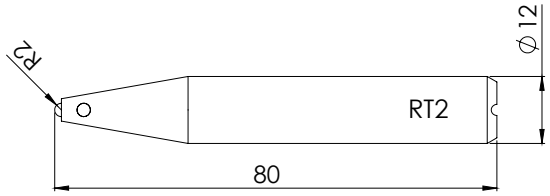
8. HOW TO CHOOSE A TOOL?



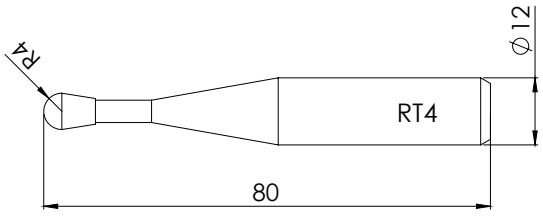
ORDERING CODE	SS	RT	15	D40	NBD	S12
HARDNESS RANGE						
Super soft	SS					
Standard	[]					
TOOL SERIES						
Teardrop		RT				
Bonnet		R				
Disc		D				
Cap		C				
Concave		CCV				
TOOL SIZE / mm			2			
			4			
			5			
			10			
			15			
	On most tooling this refers to the tool radius. On cap tools it refers to diameter.		20			
			40			
GRIT SIZE						
40				D40		
9				D9		
3				D3		
N/A	Grit size only applicable on RBD and NBD tooling.			[}		
MATERIAL						
Resin Bond					RBD	
Nickel Bond					NBD	
LP66.					LP6	
HDP					HDP	
Uninap					NAP	
Zeeko Blue					ZKB	
No Cloth					[]	
TOOLSHAFT						
12mm						S12
None (bonnet only)	All tooling with tool radius ≤15mm must come on a 12mm tool shaft.					[]

9. ZEPHYRSAG RANGE

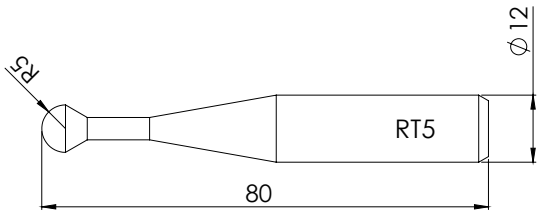
TEARDROP (RT) – STANDARD ZEPHYRSAG RANGE



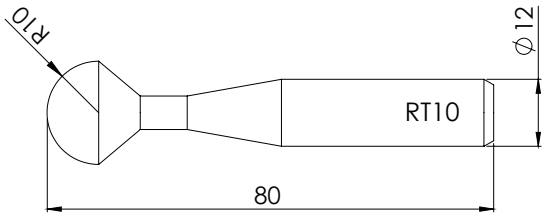
RESIN BOND (RBD)	NICKEL BOND (NBD)
RT2D40RBDS12	RT2D40NBDS12
RT2D9RBDS12	RT2D20NBDS12
RT2D3RBDS12	RT2D9NBDS12



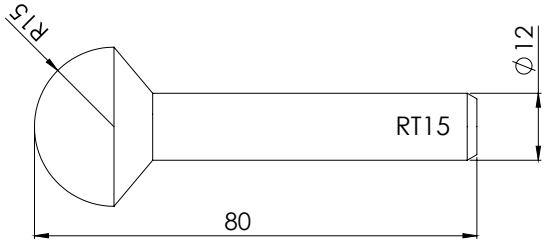
RESIN BOND (RBD)	NICKEL BOND (NBD)
RT4D40RBDS12	RT4D40NBDS12
RT4D9RBDS12	RT4D20NBDS12
RT4D3RBDS12	RT4D9NBDS12



RESIN BOND (RBD)	NICKEL BOND (NBD)
RT5D40RBDS12	RT5D40NBDS12
RT5D9RBDS12	RT5D20NBDS12
RT5D3RBDS12	RT5D9NBDS12

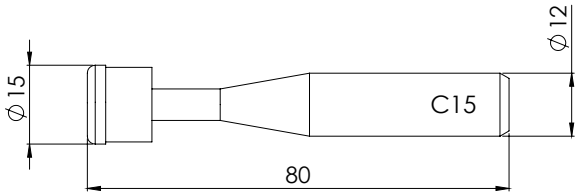


RESIN BOND (RBD)	NICKEL BOND (NBD)
RT10D40RBDS12	RT10D40NBDS12
RT10D9RBDS12	RT10D20NBDS12
RT10D3RBDS12	RT10D9NBDS12

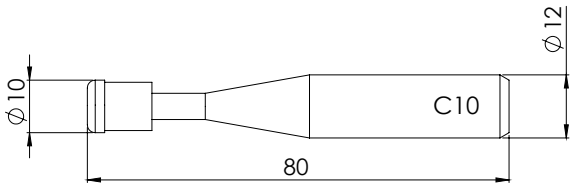


RESIN BOND (RBD)	NICKEL BOND (NBD)
RT15D40RBDS12	RT15D40NBDS12
RT15D9RBDS12	RT15D20NBDS12
RT15D3RBDS12	RT15D9NBDS12

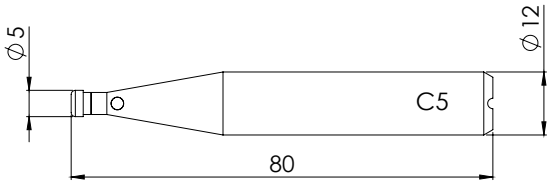
CAP (C) – STANDARD ZEPHYRSAG RANGE



RESIN BOND (RBD)	NICKEL BOND (NBD)
C5D40RBDS12	C5D40NBDS12
C5D9RBDS12	C5D20NBDS12
C5D3RBDS12	C5D9NBDS12

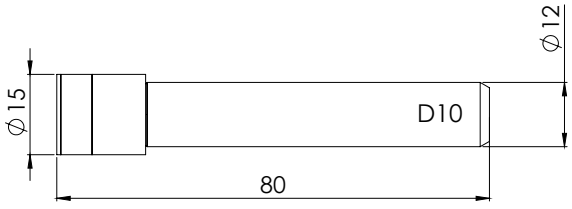


RESIN BOND (RBD)	NICKEL BOND (NBD)
C10D40RBDS12	C10D40NBDS12
C10D9RBDS12	C10D20NBDS12
C10D3RBDS12	C10D9NBDS12



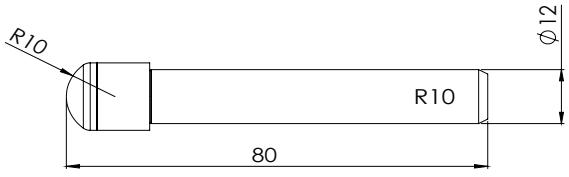
RESIN BOND (RBD)	NICKEL BOND (NBD)
C15D40RBDS12	C15D40NBDS12
C155D9RBDS12	C15D20NBDS12
C15D3RBDS12	C15D9NBDS12

DISK (D) – STANDARD ZEPHYRSAG RANGE



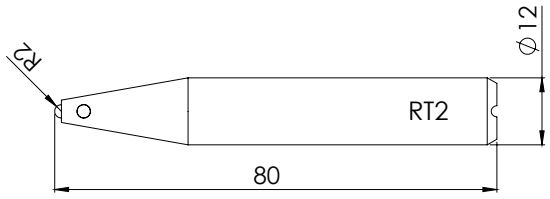
RESIN BOND (RBD)	NICKEL BOND (NBD)
D15D40RBDS12	D15D40NBDS12
D15D9RBDS12	D15D20NBDS12
D15D3RBDS12	D15D9NBDS12

RADIUS (R) – STANDARD ZEPHYRSAG RANGE

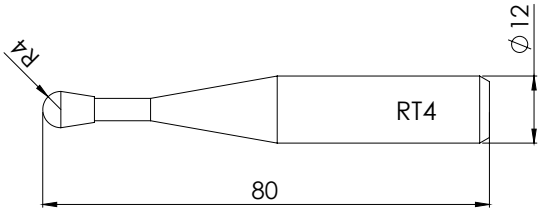


RESIN BOND (RBD)	NICKEL BOND (NBD)
R10D40RBDS12	R10D40NBDS12
R10D9RBDS12	R10D20NBDS12
R10D3RBDS12	R10D9NBDS12

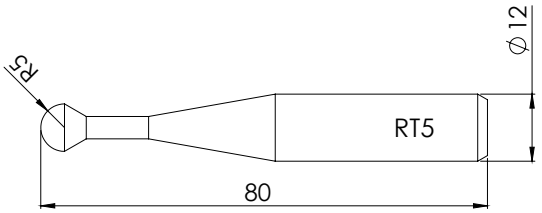
TEARDROP (RT) – SUPERSOFT ZEPHYRSAG RANGE



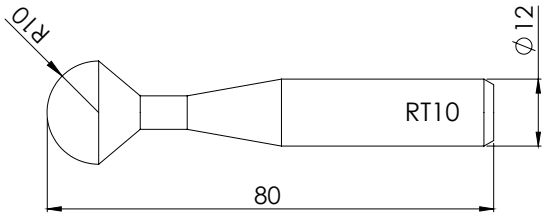
RESIN BOND (RBD)	NICKEL BOND (NBD)
SSRT2D40RBDS12	SSRT2D40NBDS12
SSRT2D9RBDS12	SSRT2D20NBDS12
SSRT2D3RBDS12	SSRT2D9NBDS12



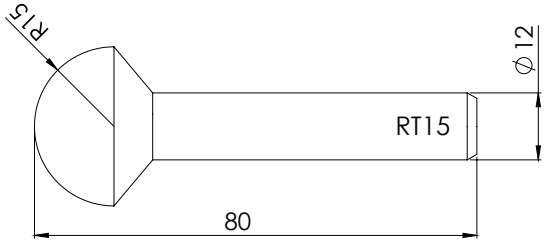
RESIN BOND (RBD)	NICKEL BOND (NBD)
SSRT4D40RBDS12	SSRT4D40NBDS12
SSRT4D9RBDS12	SSRT4D20NBDS12
SSRT4D3RBDS12	SSRT4D9NBDS12



RESIN BOND (RBD)	NICKEL BOND (NBD)
SSRT5D40RBDS12	SSRT5D40NBDS12
SSRT5D9RBDS12	SSRT5D20NBDS12
SSRT5D3RBDS12	SSRT5D9NBDS12

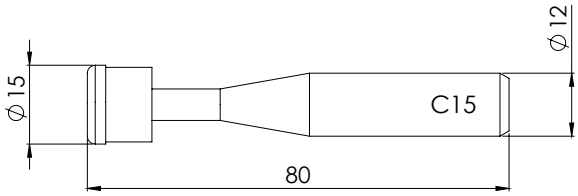


RESIN BOND (RBD)	NICKEL BOND (NBD)
SSRT10D40RBDS12	SSRT10D40NBDS12
SSRT10D9RBDS12	SSRT10D20NBDS12
SSRT10D3RBDS12	SSRT10D9NBDS12

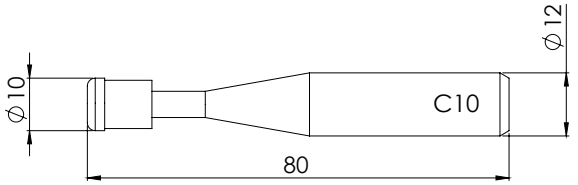


RESIN BOND (RBD)	NICKEL BOND (NBD)
SSRT15D40RBDS12	SSRT15D40NBDS12
SSRT15D9RBDS12	SSRT15D20NBDS12
SSRT15D3RBDS12	SSRT15D9NBDS12

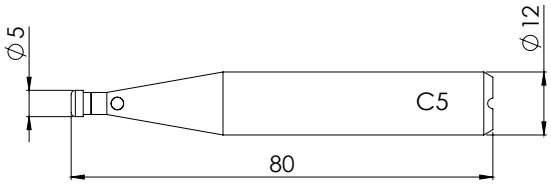
CAP (C) – SUPERSOFT ZEPHYRSAG RANGE



RESIN BOND (RBD)	NICKEL BOND (NBD)
SSC5D40RBDS12	SSC5D40NBDS12
SSC5D9RBDS12	SSC5D20NBDS12
SSC5D3RBDS12	SSC52D9NBDS12

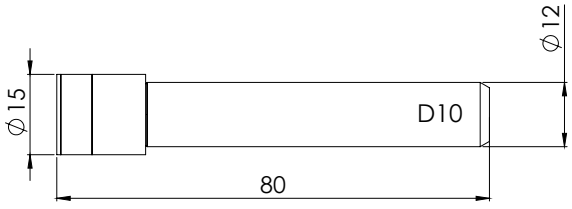


RESIN BOND (RBD)	NICKEL BOND (NBD)
SSC10D40RBDS12	SSC10D40NBDS12
SSC10D9RBDS12	SSC10D20NBDS12
SSC10D3RBDS12	SSC10D9NBDS12



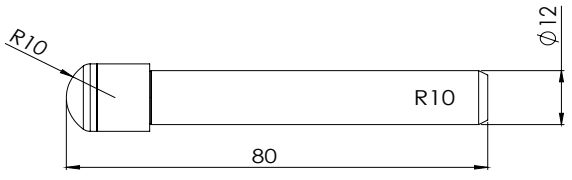
RESIN BOND (RBD)	NICKEL BOND (NBD)
SSC15D40RBDS12	SSC15D40NBDS12
SSC155D9RBDS12	SSC15D20NBDS12
SSC15D3RBDS12	SSC15D9NBDS12

DISK (D) – SUPERSOFT ZEPHYRSAG RANGE



RESIN BOND (RBD)	NICKEL BOND (NBD)
SSD15D40RBDS12	SSD15D40NBDS12
SSD15D9RBDS12	SSD15D20NBDS12
SSD15D3RBDS12	SSD15D9NBDS12

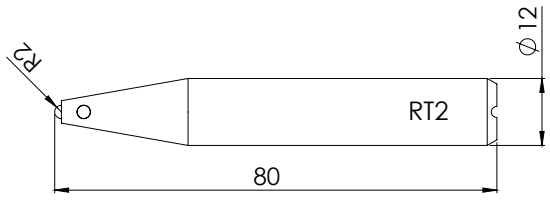
RADIUS (R) – SUPERSOFT ZEPHYRSAG RANGE



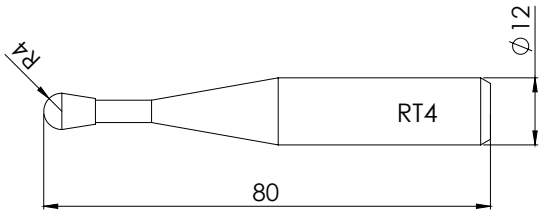
RESIN BOND (RBD)	NICKEL BOND (NBD)
SSR10D40RBDS12	SSR10D40NBDS12
SSR10D9RBDS12	SSR10D20NBDS12
SSR10D3RBDS12	SSR10D9NBDS12

10. ZEPHYR POLISHING RANGE

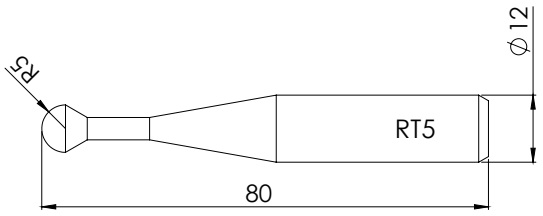
TEARDROP (RT) – STANDARD ZEPHYR POLISHING RANGE



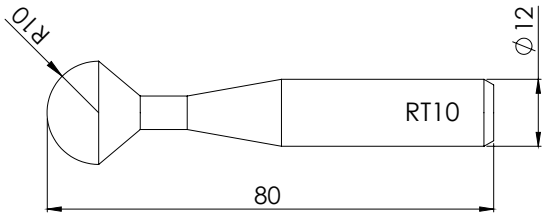
POLYURETHANE	ZEEKOBLUE
RT2LP66S12 RT2HDPUS12	RT2ZKOBLUES12



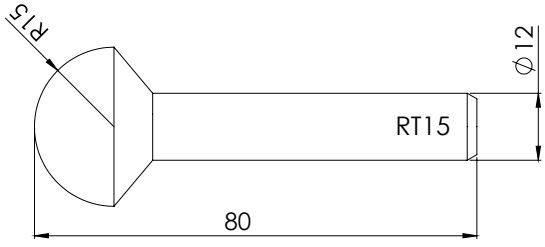
POLYURETHANE	ZEEKOBLUE
RT4LP66S12 RT4HDPUS12	RT4ZKOBLUES12



POLYURETHANE	ZEEKOBLUE
RT5LP66S12 RT5HDPUS12	RT5ZKOBLUES12

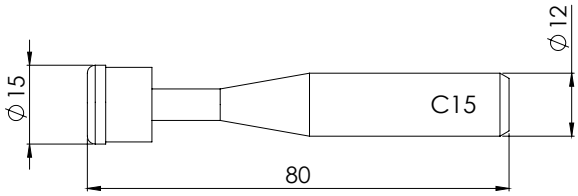


POLYURETHANE	ZEEKOBLUE
RT10LP66S12 RT10HDPUS12	RT10ZKOBLUES12

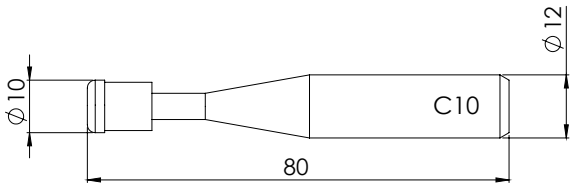


POLYURETHANE	ZEEKOBLUE
RT15LP66S12 RT15HDPUS12	RT15ZKOBLUES12

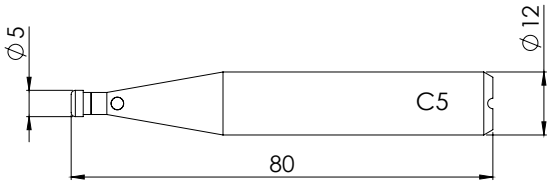
CAP (C) – STANDARD ZEPHYR POLISHING RANGE



POLYURETHANE	ZEEKOBLUE
C5LP66S12 C5HDPUS12	C5ZKOBLUES12

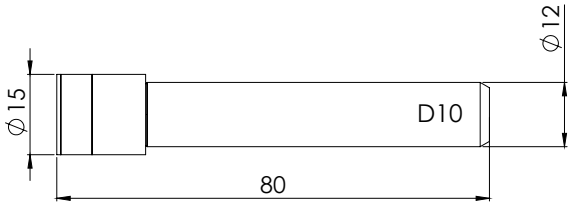


POLYURETHANE	ZEEKOBLUE
C10LP66S12 C10HDPUS12	C10ZKOBLUES12



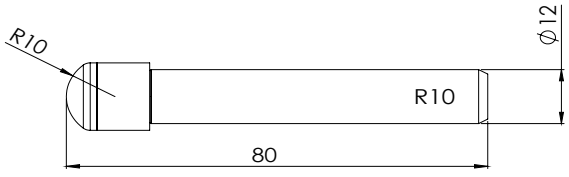
POLYURETHANE	ZEEKOBLUE
C15LP66S12 C15HDPUS12	C15ZKOBLUES12

DISK (D) – STANDARD ZEPHYR POLISHING RANGE



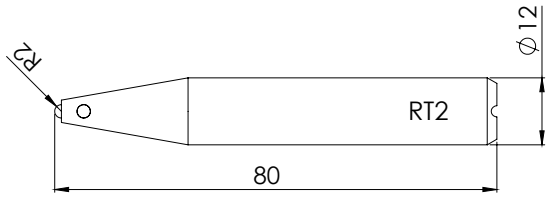
POLYURETHANE	ZEEKOBLUE
D15LP66S12 D15HDPUS12	D15ZKOBLUES12

RADIUS (R) – STANDARD ZEPHYR POLISHING RANGE

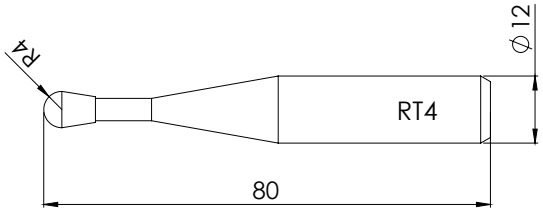


POLYURETHANE	ZEEKOBLUE
R10LP66S12 R10HDPUS12	R10ZKOBLUES12

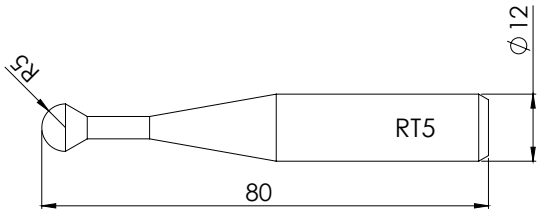
TEARDROP (RT) – SUPERSOFT ZEPHYR POLISHING RANGE



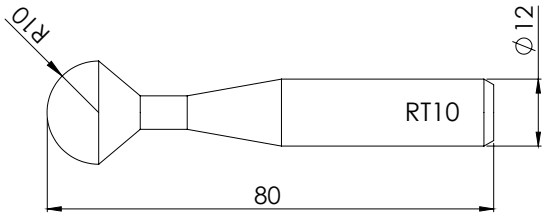
POLYURETHANE	ZEEKOBLUE
SSRT2LP66S12 SSRT2HDPUS12	SSRT2ZKOBLUES12



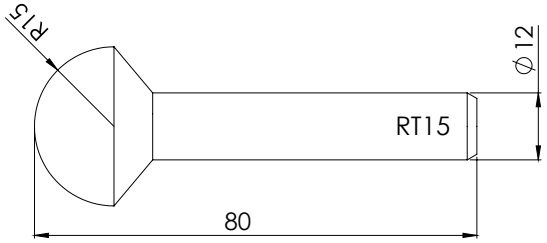
POLYURETHANE	ZEEKOBLUE
SSRT4LP66S12 SSRT4HDPUS12	SSRT4ZKOBLUES12



POLYURETHANE	ZEEKOBLUE
SSRT5LP66S12 SSRT5HDPUS12	SSRT5ZKOBLUES12

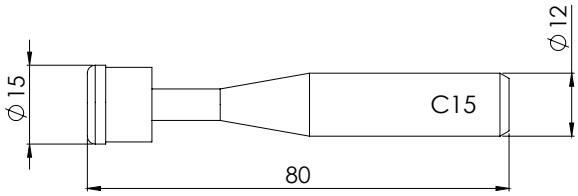


POLYURETHANE	ZEEKOBLUE
SSRT10LP66S12 SSRT10HDPUS12	SSRT10ZKOBLUES12

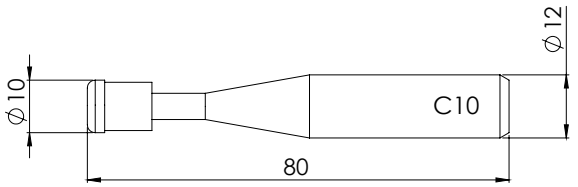


POLYURETHANE	ZEEKOBLUE
SSRT15LP66S12 SSRT15HDPUS12	SSRT15ZKOBLUES12

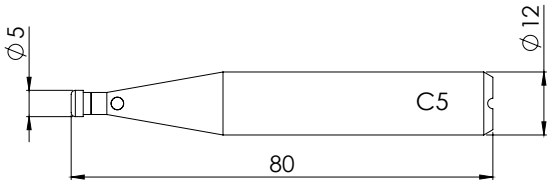
CAP (C) – SUPERSOFT ZEPHYR POLISHING RANGE



POLYURETHANE	ZEEKOBLUE
SSC5LP66S12 SSC5HDPUS12	SSC5ZKOBLUES12

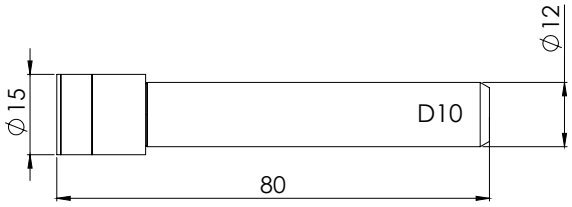


POLYURETHANE	ZEEKOBLUE
SSC10LP66S12 SSC10HDPUS12	SSC10ZKOBLUES12



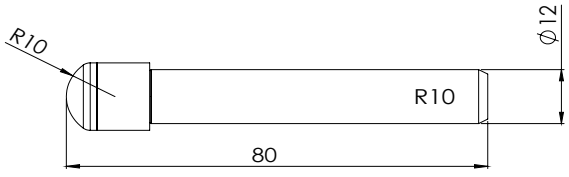
POLYURETHANE	ZEEKOBLUE
SSC15LP66S12 SSC15HDPUS12	SSC15ZKOBLUES12

DISK (D) – SUPERSOFT ZEPHYR POLSIHING RANGE



POLYURETHANE	ZEEKOBLUE
SSD15LP66S12 SSD15HDPUS12	SSD15ZKOBLUES12

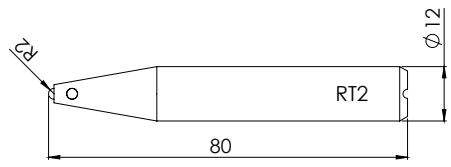
RADIUS (R) – SUPERSOFT ZEPHYR POLISHING RANGE



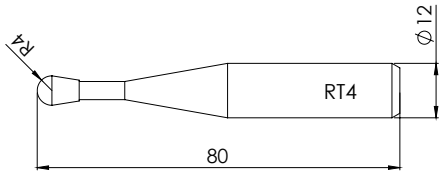
POLYURETHANE	ZEEKOBLUE
SSR10LP66S12 SSR10HDPUS12	SSR10ZKOBLUES12

11. SAFE PROCESS PARAMETERS

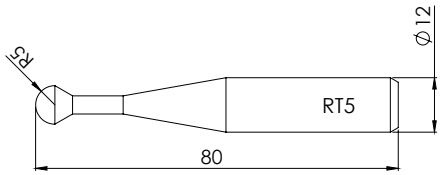
TEARDROP (RT) – STANDARD ZEPHYRSAG RANGE



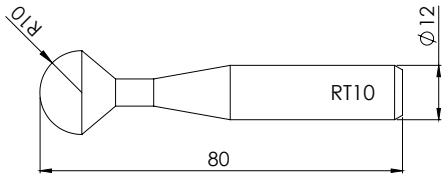
PARAMETER	RESIN	NICKEL
Track Spacing	0.1	0.1
Tool Offset	0.15	0.15
Tool Feed	100 – 3000 mm/min (IRP Machines)	100 – 3000 mm/min (IRP Machines)
Tool Spindle	50-3000 rpm 50-24000 rpm (Robodrill)	50-3000 rpm 50-24000 rpm (Robodrill)



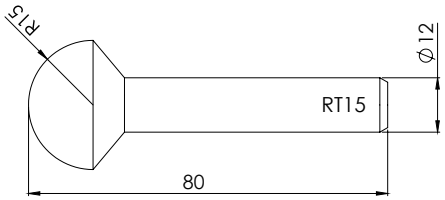
PARAMETER	RESIN	NICKEL
Track Spacing	0.15	0.15
Tool Offset	0.3	0.3
Tool Feed	500mm/min	500mm/min
Tool Spindle	10,000-12,000 RPM	6000-10,000 RPM



PARAMETER	RESIN	NICKEL
Track Spacing	0.17	0.17
Tool Offset	0.3	0.3
Tool Feed	500mm/min	500mm/min
Tool Spindle	10,000-12,000 RPM	6000-10,000 RPM

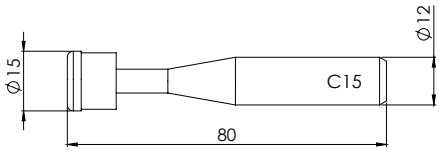


PARAMETER	RESIN	NICKEL
Track Spacing	0.35	0.35
Tool Offset	0.3	0.3
Tool Feed	500mm/min	500mm/min
Tool Spindle	10,000-12,000 RPM	6000-10,000 RPM

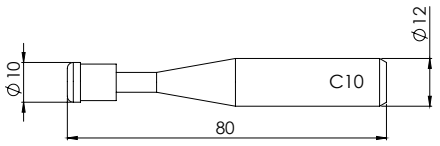


PARAMETER	RESIN	NICKEL
Track Spacing	0.35	0.35
Tool Offset	0.3	0.3
Tool Feed	500mm/min	500mm/min
Tool Spindle	10,000-12,000 RPM	6000-10,000 RPM

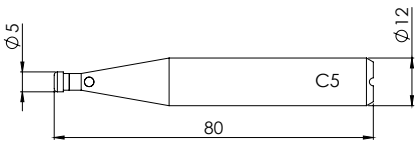
CAP (C) – STANDARD ZEPHYRSAG RANGE



PARAMETER	RESIN	NICKEL
Track Spacing	0.25	0.25
Tool Offset	0.3	0.3
Tool Feed	500mm/min	500mm/min
Tool Spindle	10,000-12,000 RPM	6000-10,000 RPM

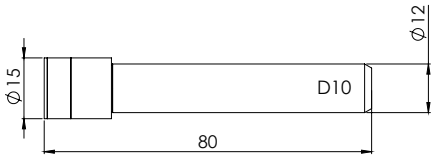


PARAMETER	RESIN	NICKEL
Track Spacing	0.35	0.35
Tool Offset	0.3	0.3
Tool Feed	500mm/min	500mm/min
Tool Spindle	10,000-12,000 RPM	6000-10,000 RPM



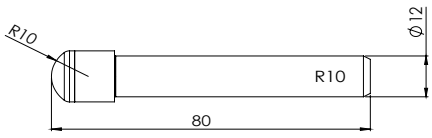
PARAMETER	RESIN	NICKEL
Track Spacing	0.5	0.5
Tool Offset	0.3	0.3
Tool Feed	500mm/min	500mm/min
Tool Spindle	10,000-12,000 RPM	6000-10,000 RPM

DISK (D) – STANDARD ZEPHYRSAG RANGE



PARAMETER	RESIN	NICKEL
Track Spacing	0.5	0.5
Tool Offset	0.3	0.3
Tool Feed	500mm/min	500mm/min
Tool Spindle	10,000-12,000 RPM	6000-10,000 RPM

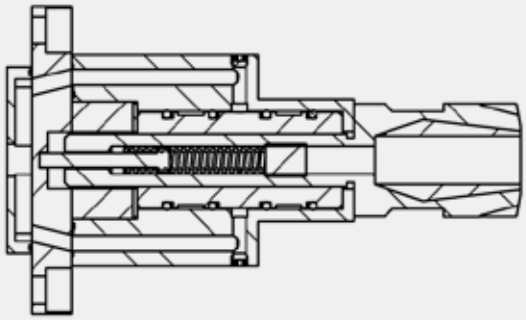
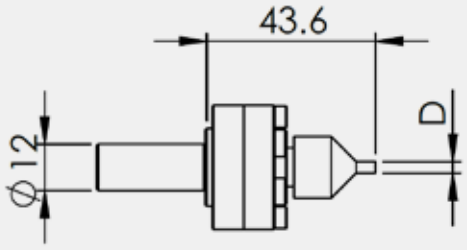
RADIUS (R) – STANDARD ZEPHYRSAG RANGE



PARAMETER	RESIN	NICKEL
Track Spacing	0.25	0.12
Tool Offset	0.3	0.3
Tool Feed	500mm/min	500mm/min
Tool Spindle	10,000-12,000 RPM	6000-10,000 RPM

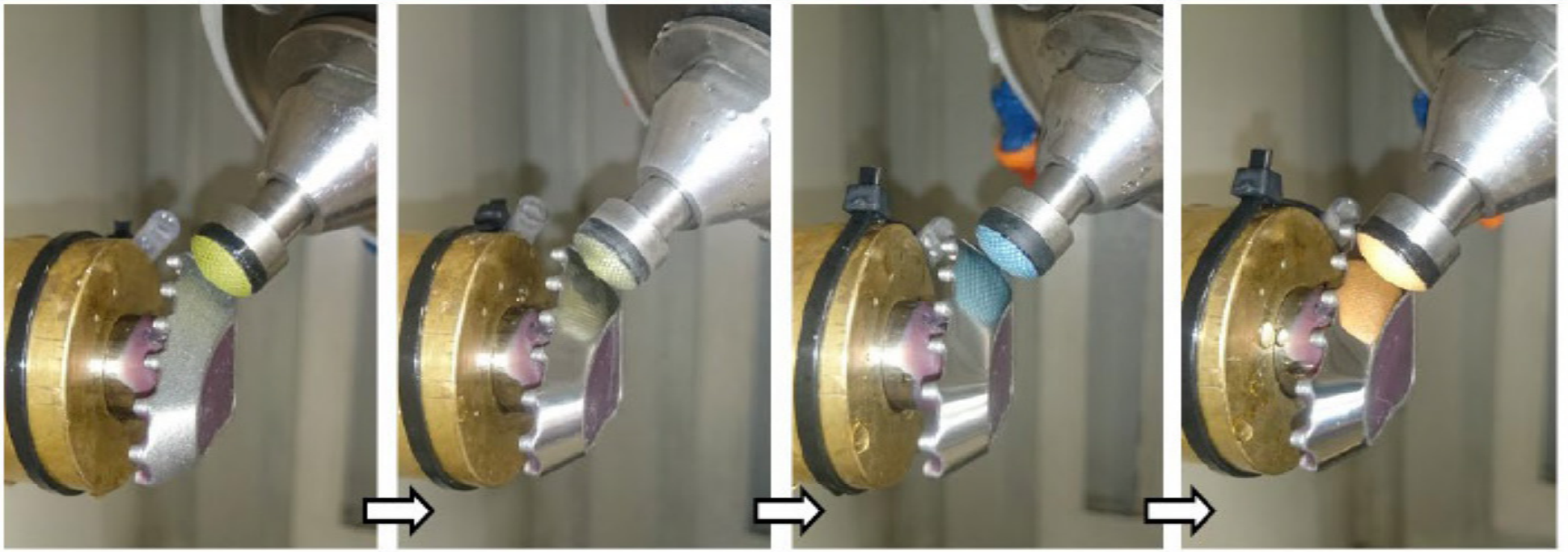
12. ACCESSORIES

1.1 SPECIALIST TOOLHOLDERS

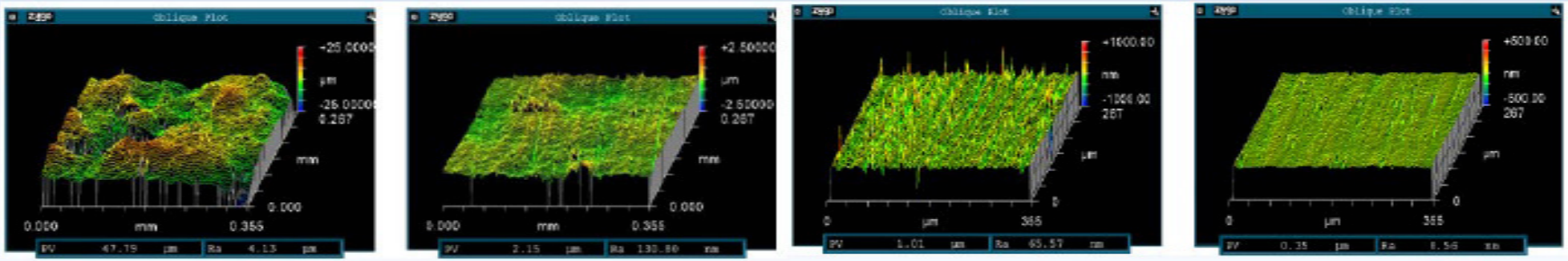
ASSEMBLY	PART NUMBER	DESCRIPTION
Constant Force Toolholder (CFT) - 12mm shank  If a STEP File is required, please email Zeeko info@zeeko.co.uk Zeeko's selection of Constant Force Tool Holders utilise latest precision air bushings to provide a linear range of motion to the tool head during machining operations. They have been designed specifically to work alongside our RPC machine range to counteract any vertical "Nodding", an issue often found in 6-axis robot arms, so that a near constant force can be applied at the polishing spot. We also see uses in parts with particularly large surface deviation, where the tool can follow any surface imperfections while still maintaining a similar polishing spot size.	YB100-000009	This CFT toolholder is normally only used with pitch tools, but can (with special tools and under special direction) be recommended for use with small SAG tools. It mounts directly to the front face of the 200/400 H-axis (with Schunk chuck removed). It requires dialing in to ensure correct performance. It is to be used with 12mm tool shafts (held in a collet) The Constant Force Tool Range currently has a variety of mounting options for machines and is constantly evolving as we improve existing designs and trial new ones.
Spring Loaded CFT for use with Pitch tools 	LB100-000007	Designed for use without an air supply, this Spring loaded CFT allows for pitch polishing on any machine tool capable of holding the 12mm shank. Various tip sizes (D) available from 3mm to 10mm.

"SAG" Grinding of manufactured workpiece: Roughness

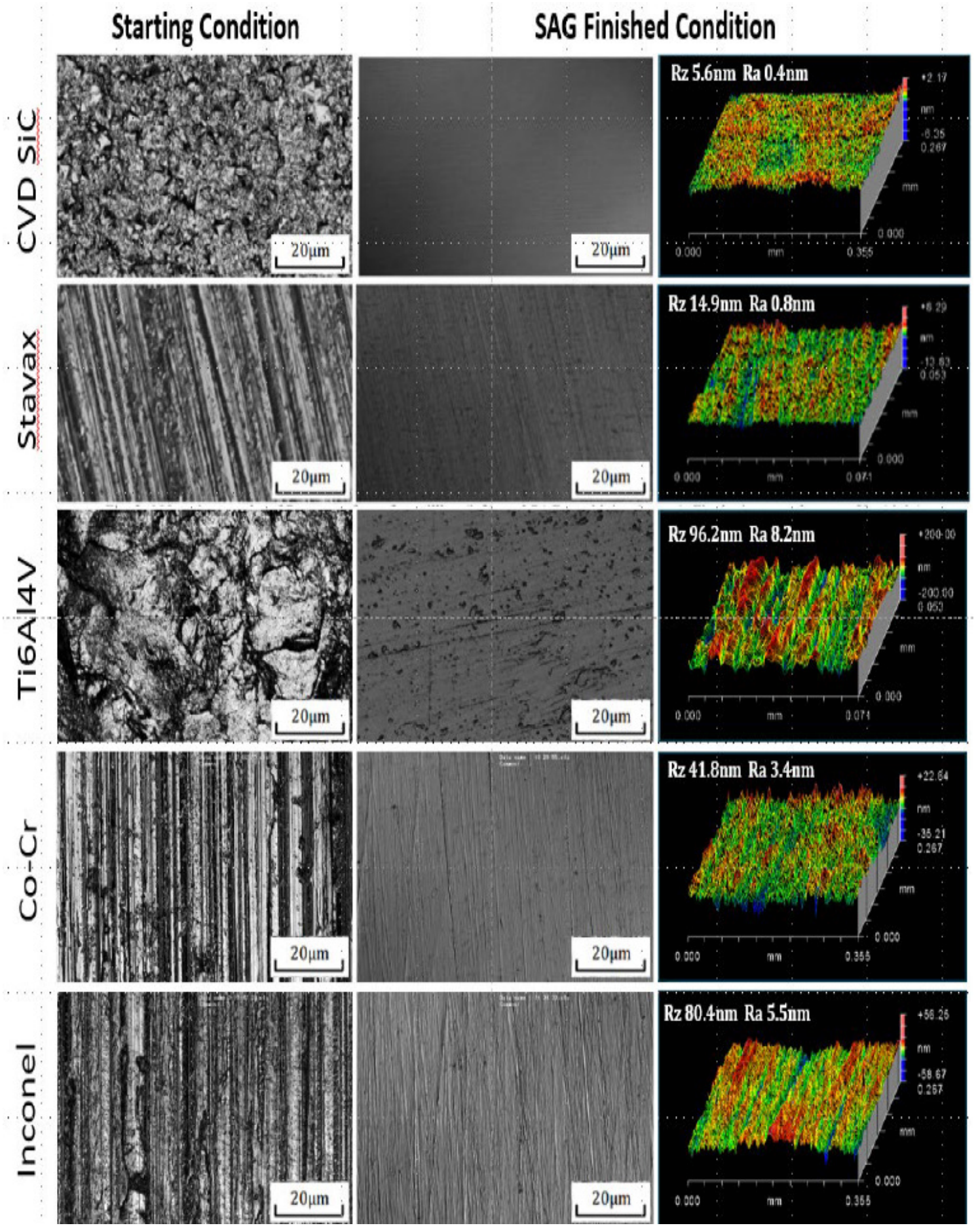
Finishing of titanium alloy (Ti4Al6V) component produced by Selective Laser Sintering.



(a) As received (b) Nickel bonded 40 µm (c) Nickel bonded 9 µm (d) Resin bonded 3 µm



Roughness: Ra 4130 nm Ra 130 nm Ra 65 nm Ra 8 nm


Starting Condition
SAG Finished Condition
CVD SiC
Stavax
Ti6Al4V
Co-Cr
Inconel
20µm
Rz 5.6nm Ra 0.4nm
Rz 14.9nm Ra 0.8nm
Rz 96.2nm Ra 8.2nm
Rz 41.8nm Ra 3.4nm
Rz 80.4nm Ra 5.5nm

SAG·Tek

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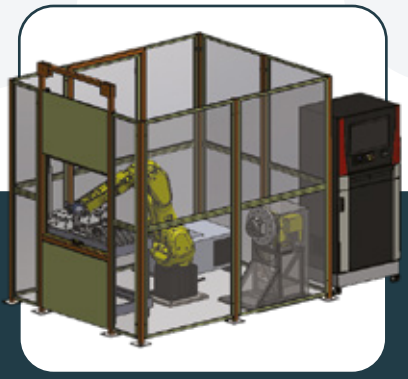
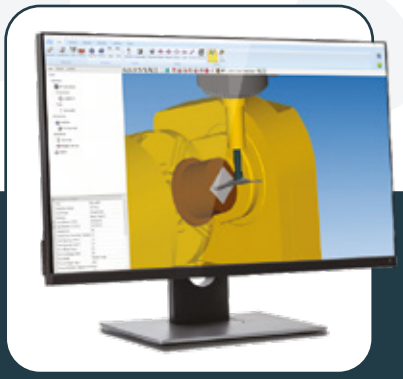
SHAPE ADAPTIVE GRINDING (SAG)



ROBOT POLISHING CELL (RPC)



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