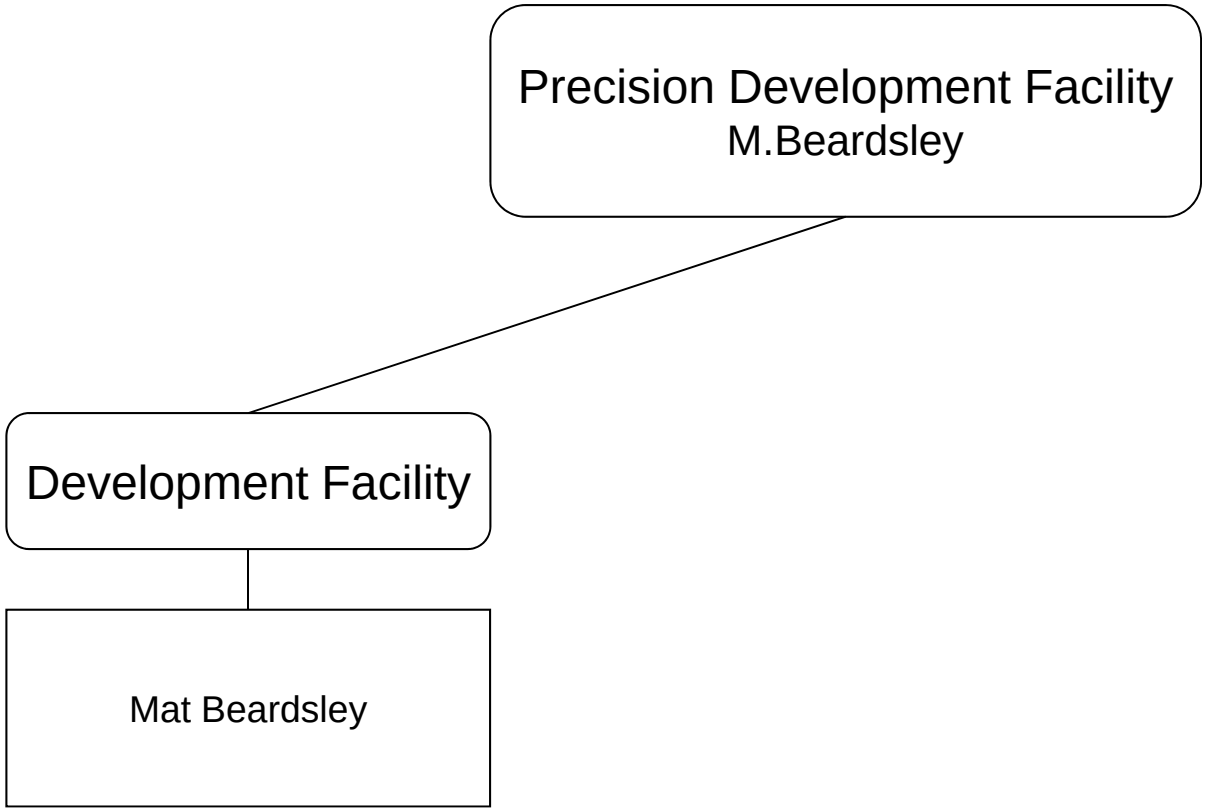
Manufacture of Precision Novel Geometries for Laser Science

M.Beardsley

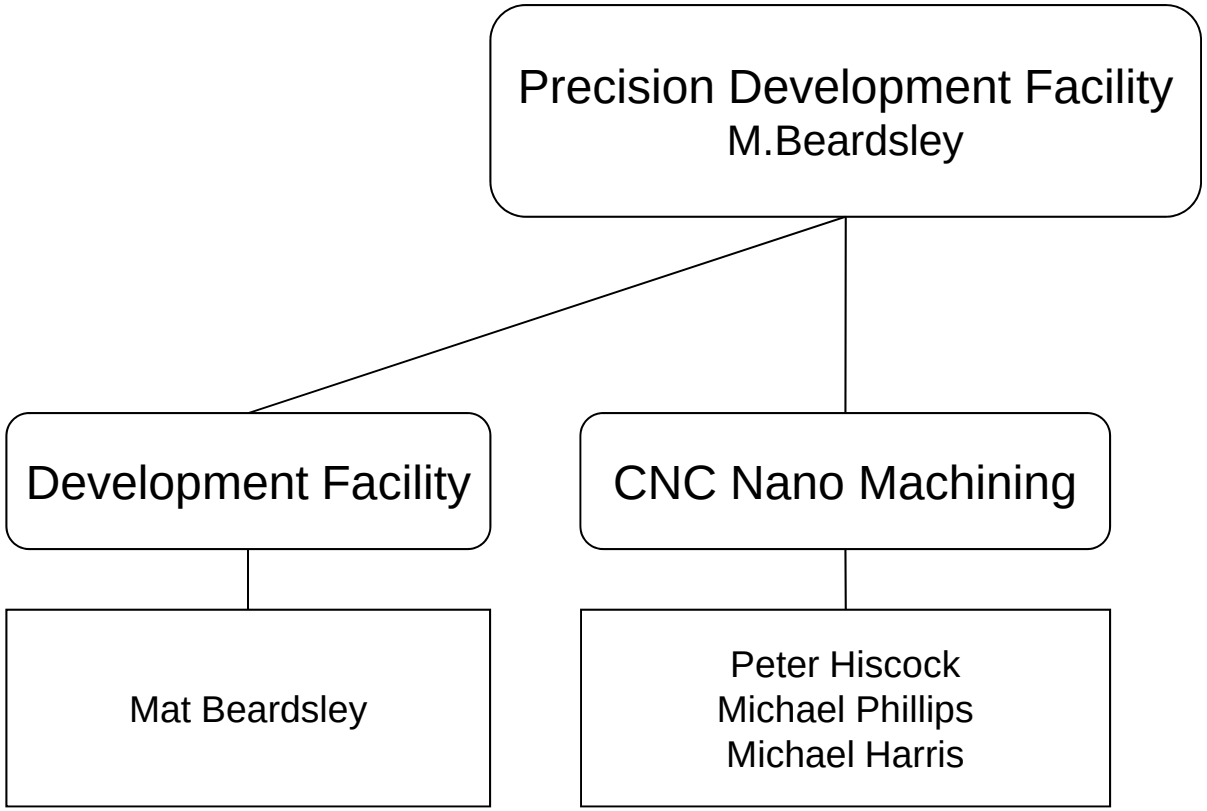
RAL Space

PDF Organagram



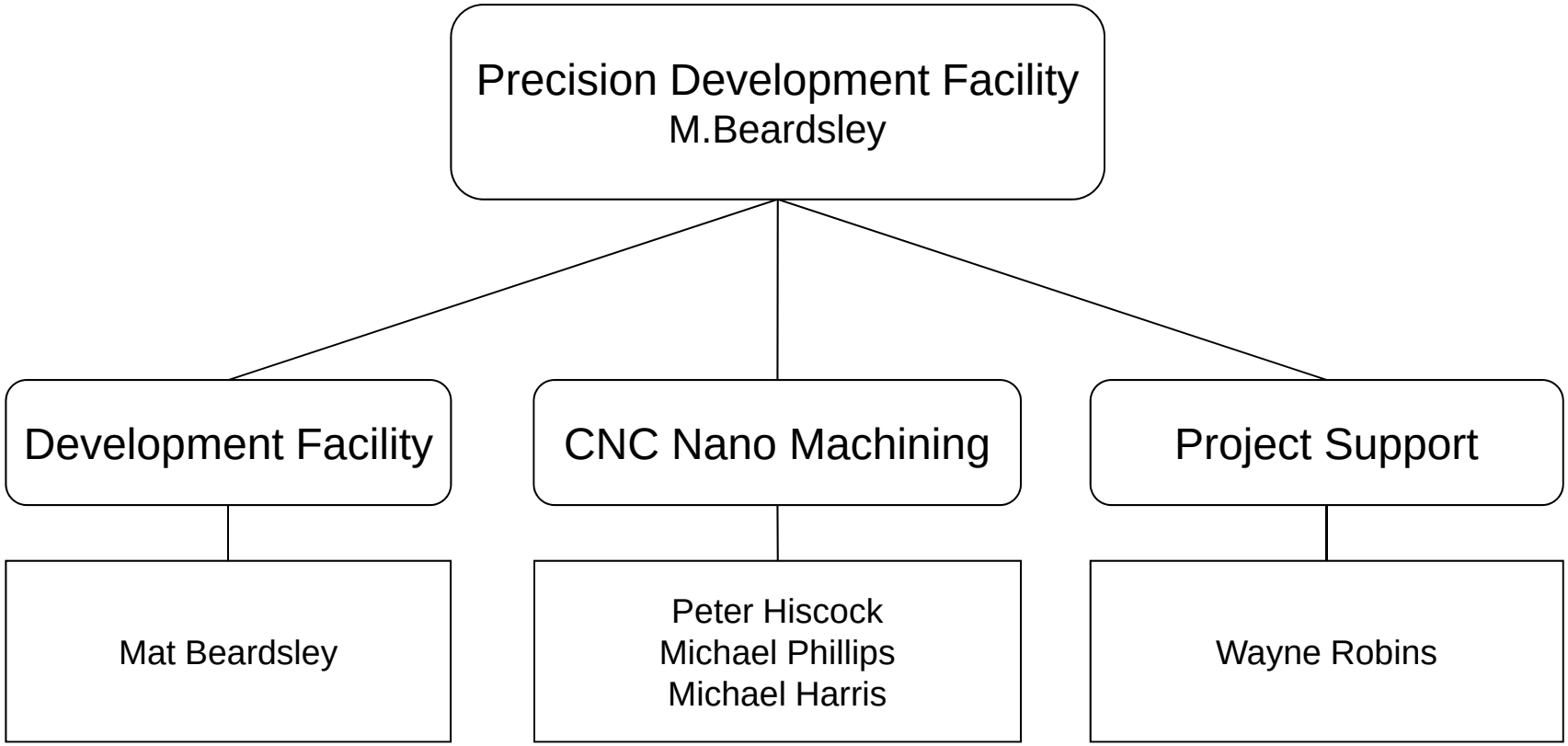
Development Facility

PDF Organagram

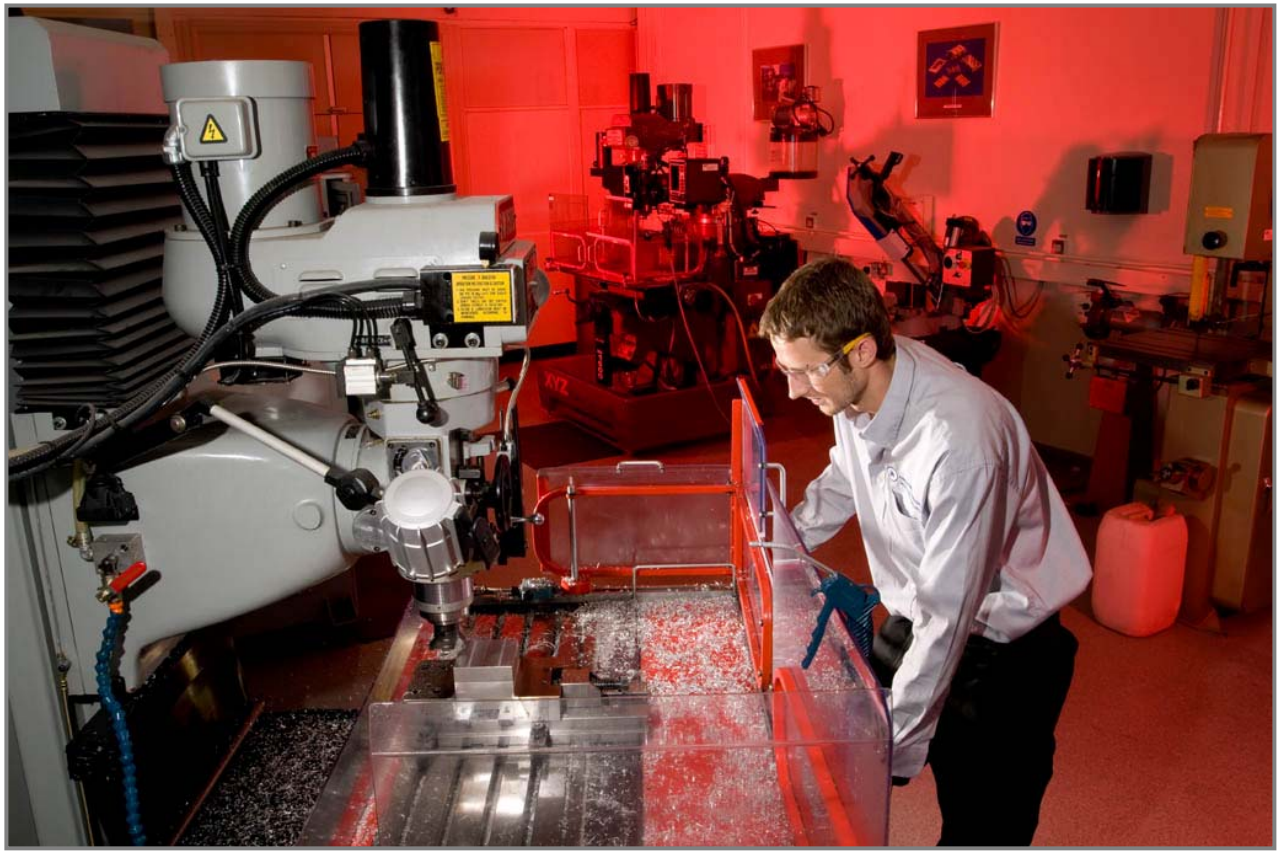


CNC Nano Machining

PDF Organagram



Project Support



Objectives of the Facility

- **Primarily developing and manufacturing devices operating in the microwave frequency range.**
- **Close support role for other Departments at the Rutherford Laboratory and commercial companies**

  Laser, ISIS, OXSENSIS, QinetiQ

Development of novel machining techniques.
Production of miniature components

Target Manufacture

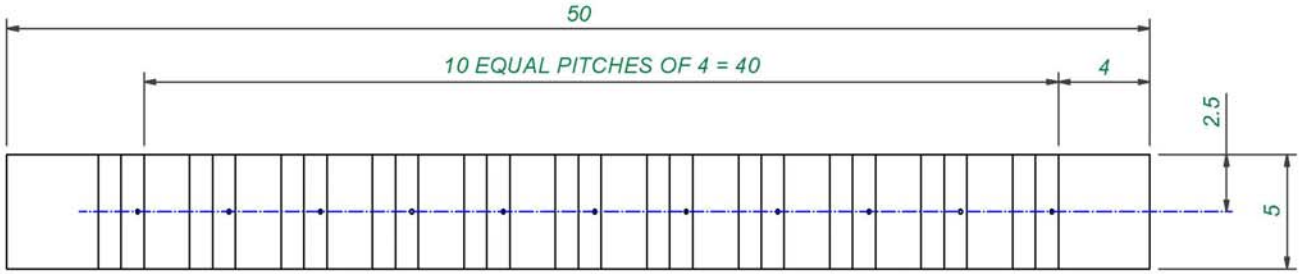
Example Geometries

- Foam and Dimple – 200 micron dimple
- Free Standing Tapered Wire – 100 micron tapering to tip of 50 micron
- Iron Staircase – 10 micron step heights

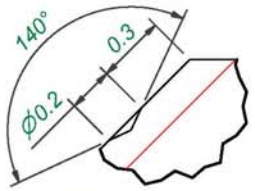
A3 | SL-4510-143-00

PROJECTION

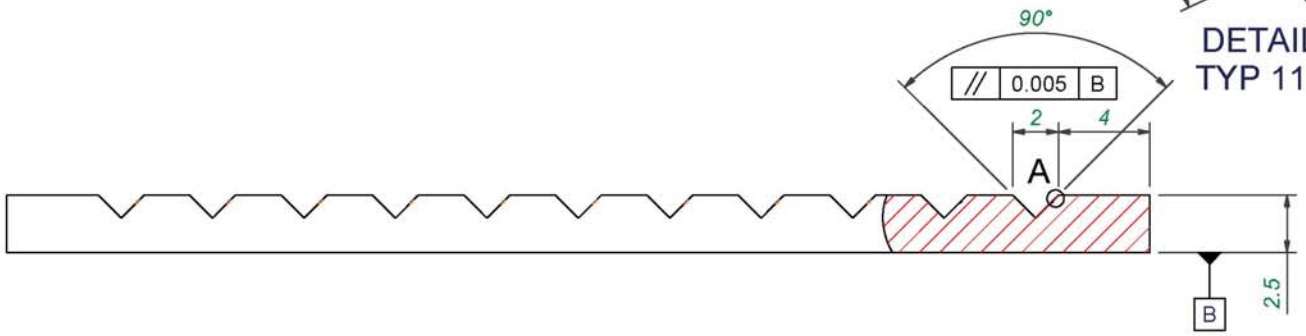
THIS DRAWING CONFORMS TO B.S.8888



ISOMETRIC VIEW
SCALE 1:1



DETAIL A (50 : 1)
TYP 11 POSITIONS



ISSUE	DATE	MODIFICATION DESCRIPTION	DRN.	CHKD.	APPD.	STATUS
A	30/04/2007		GJ	GJ		

USED ON SL-4510-137-00

C.C.L.R.C.-RUTHERFORD APPLETON LAB. OX11-0QX

TOLERANCE UNLESS STATED	FINISH	ORIGINAL SCALE
± 0.1	CLEAN REMOVE ALL BURRS	5:1 DO NOT SCALE
MATERIAL & SPEC.	SURFACE FINISH µm	0 10 mm
AL ALLOY TO BS1470/6082/0	1.6 ✓ UNLESS STATED	

TITLE

TARGET 45 DEGREE DIMPLED

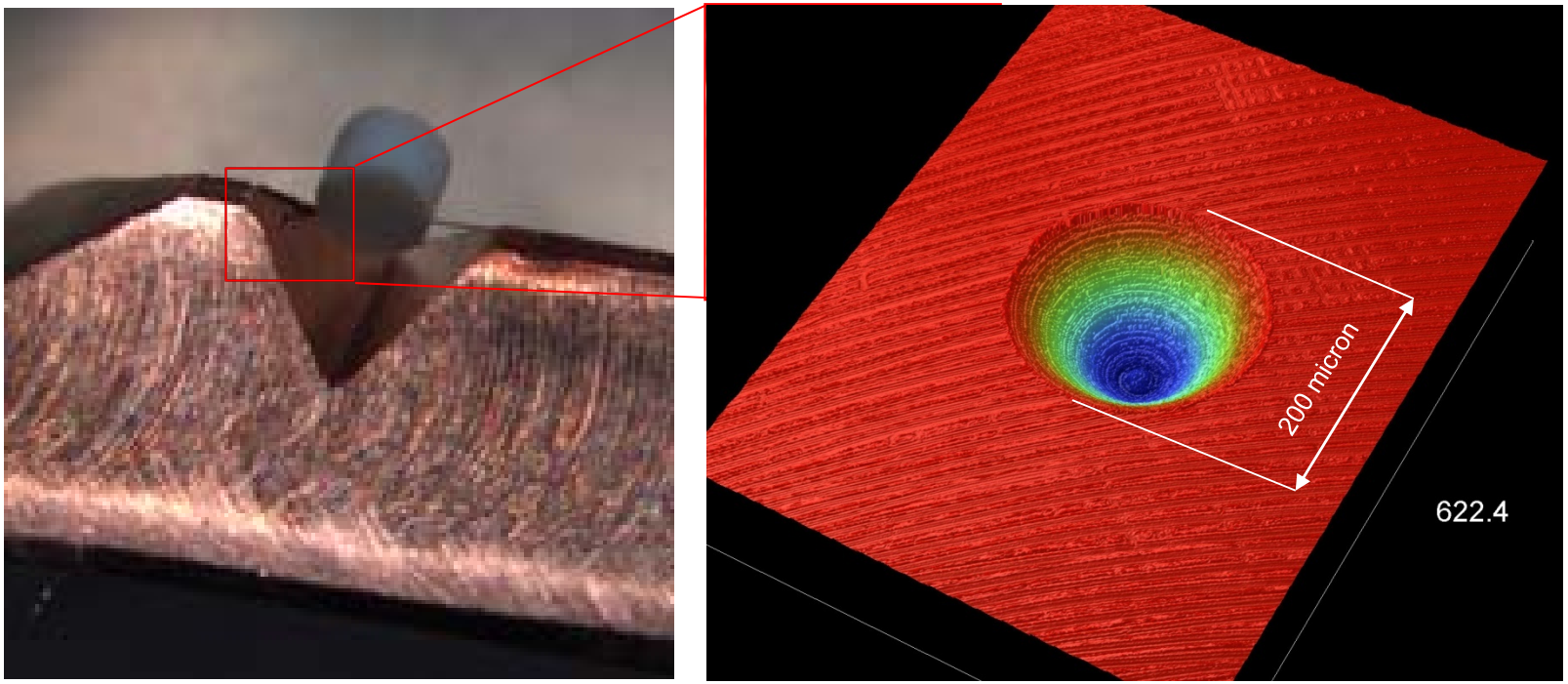
A3 | SL-4510-143-00 | REV A

SL-4510-143-00 | A3

Foam and dimple

Dimple machined on an angular face 35 microns deep

Material: Copper
Machine: Manual Precision Micro Mill



A3 | TAP-0708-0002

PROJECTION

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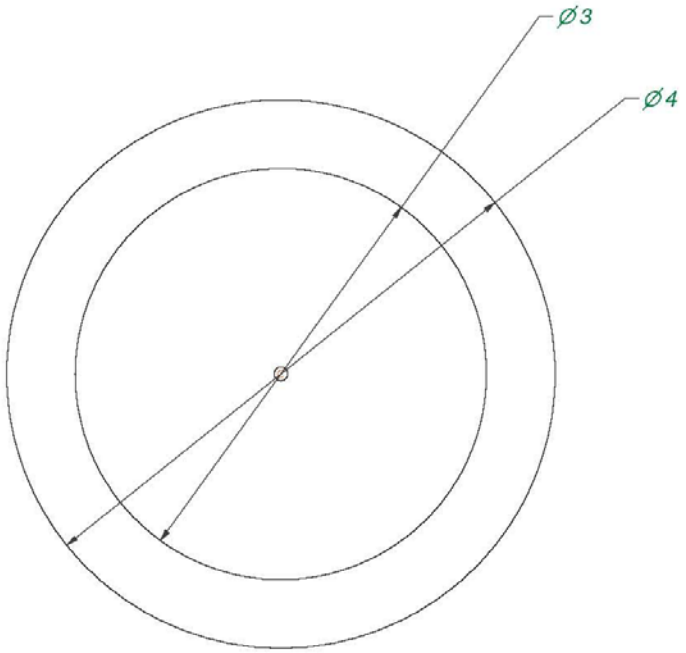
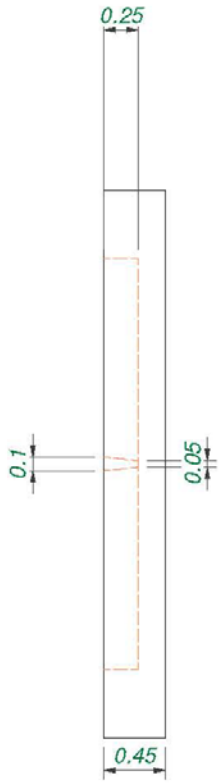
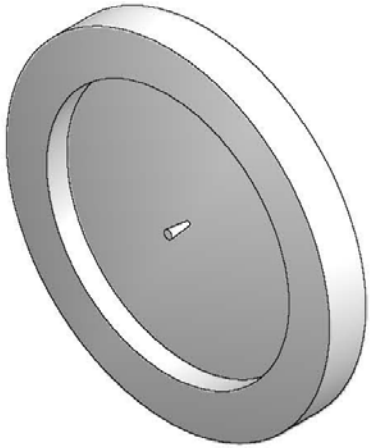






ISSUE	DATE	MODIFICATION DESCRIPTION	DRN.	CHKD.	APPD.	STATUS
A	07/07/2008		CS			

USED ON

S.T.F.C. - RUTHERFORD APPLETON LAB. OX11-0QX

A3 TAP-0708-0002

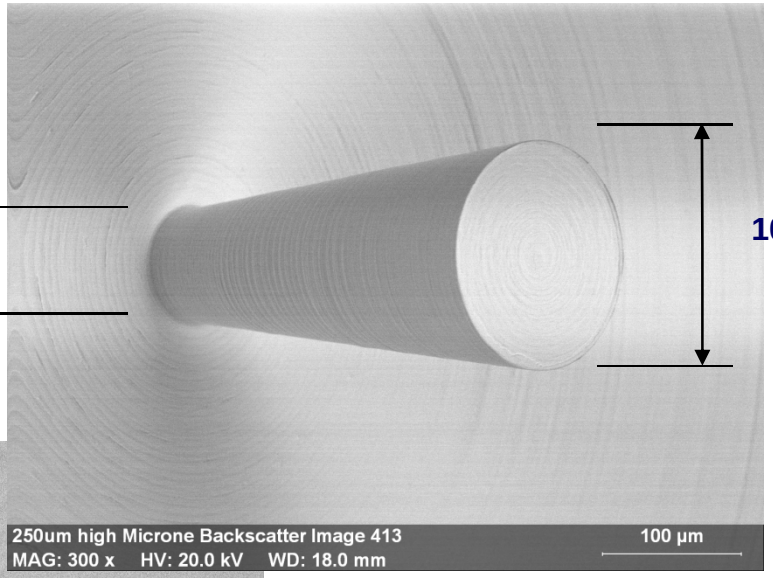
TOLERANCE UNLESS STATED	FINISH	ORIGINAL SCALE
± 0.1	CLEAN REMOVE ALL BURRS	DO NOT SCALE
MATERIAL & SPEC.	SURFACE FINISH µm	0 mm
Fe	1.6 ✓ UNLESS STATED	

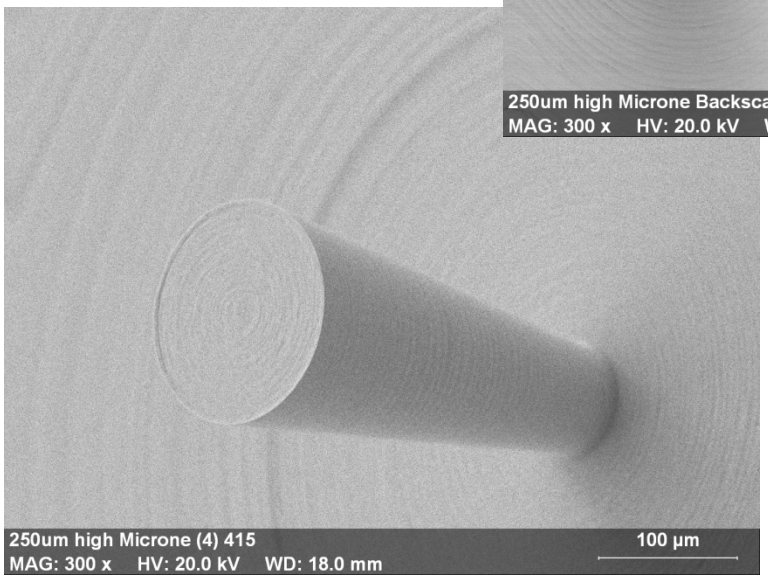
TITLE

Embedded Cone

A3 | TAP-0708-0002 | REV

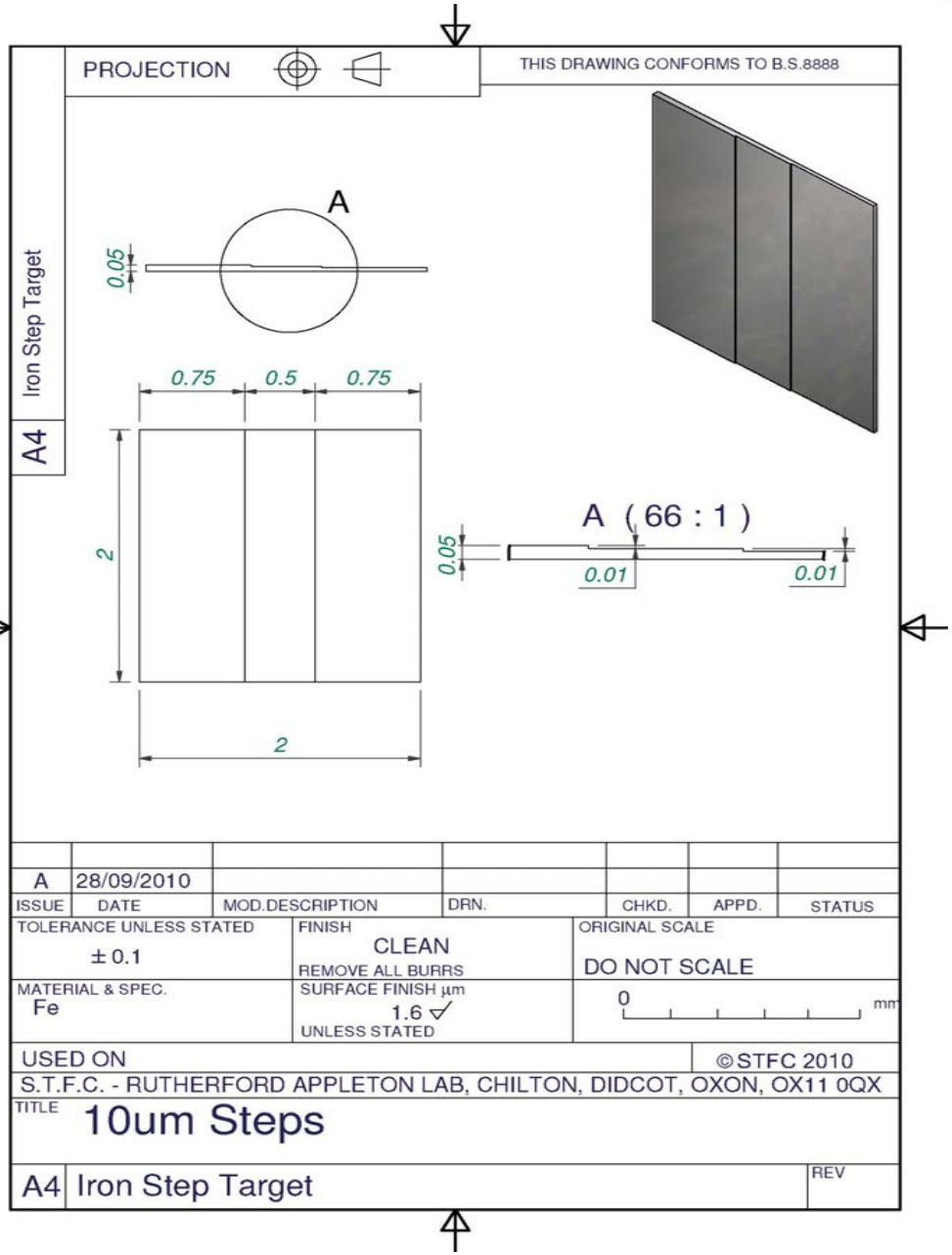
Free Standing Wire - 250 micron





Material: Iron

Machine: Manual Hardinge Lathe

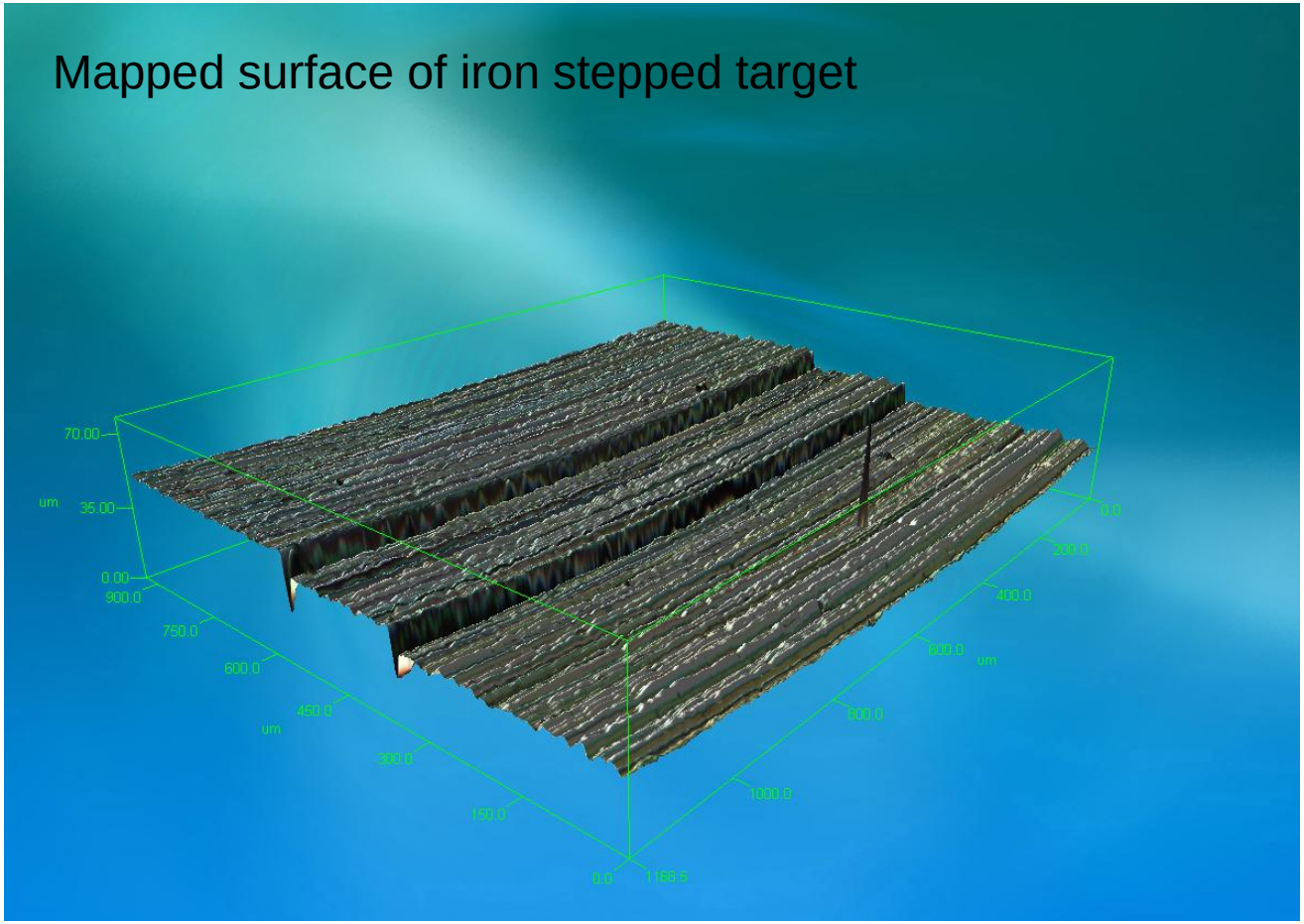


Material: Iron

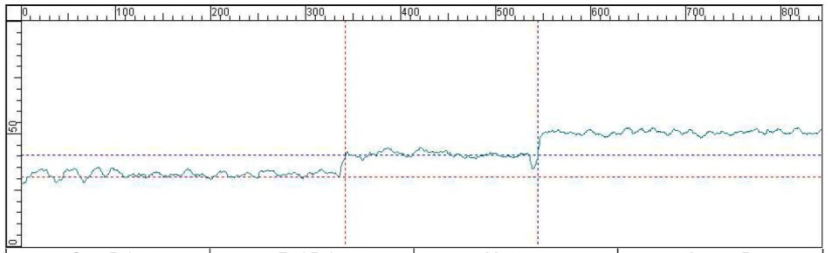
Machine: SIXIS Jig Borer

Machined using unconventional machine techniques unique to the PDF to achieve high levels of surface finish and accurate step heights

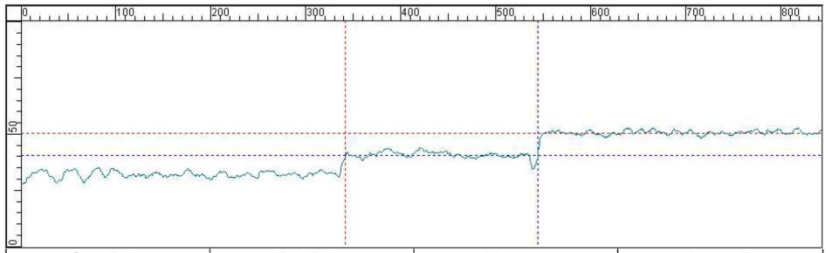
Step Targets



Gabriel Step Target 10, 20, 30um Steps

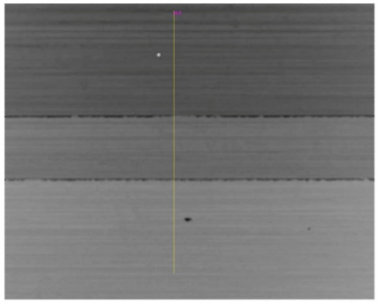


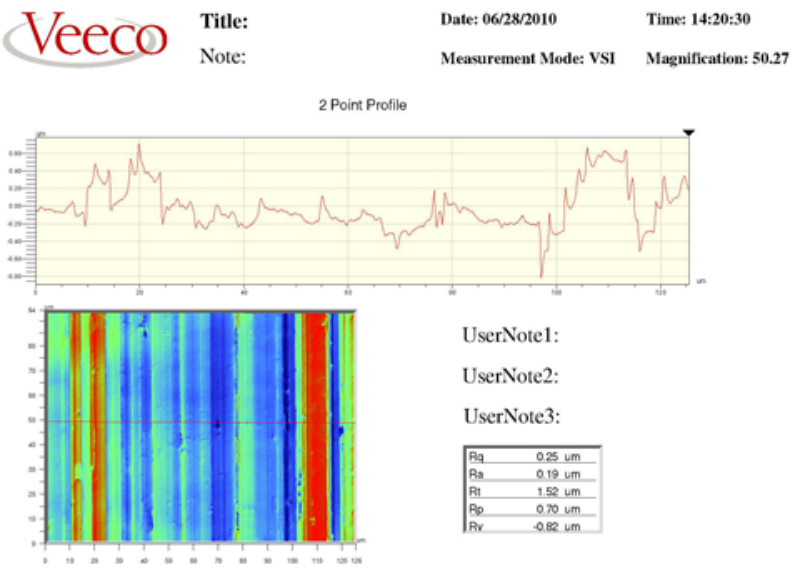
Start Point	End Point	Measure	Approx.R
X = 542.993 um Y = 363.231 um Z = 30.948 um	X = 542.993 um Y = 567.085 um Z = 40.741 um	Height : 9.794 um Length : 203.854 um Distance : 204.089 um Angle : 2.751 deg	CenterX : ------ CenterY : ------ CenterZ : ------ Radius : ------



Start Point	End Point	Measure	Approx.R
X = 542.993 um Y = 363.231 um Z = 50.535 um	X = 542.993 um Y = 567.085 um Z = 40.741 um	Height : 9.794 um Length : 203.854 um Distance : 204.089 um Angle : -2.751 deg	CenterX : ------ CenterY : ------ CenterZ : ------ Radius : ------

Step height measurements





Surface roughness measurements typically 0.19 Ra

Target Manufacture

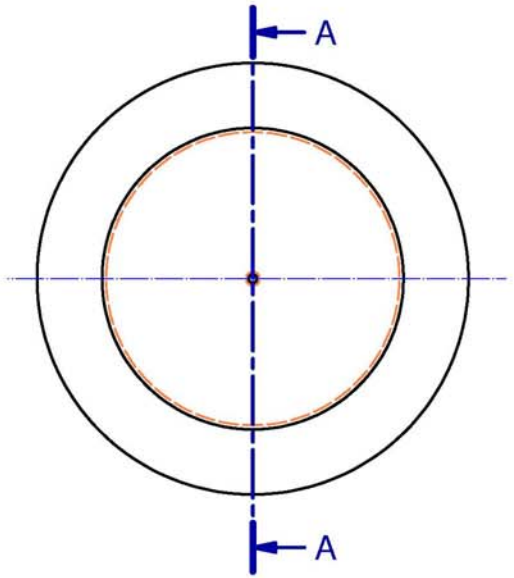
Complex Cones & Mass manufacture

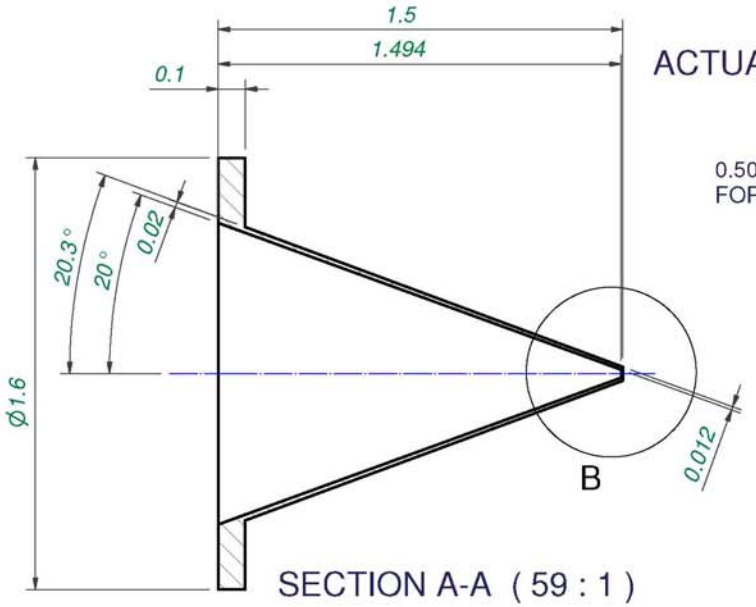
- Carried out feasibility on KERN Micro
- Enhanced the development on KERN Pyramid Nano
- Demonstrating mass manufacture of cones

A3 | SL-3000-472-00

PROJECTION

THIS DRAWING CONFORMS TO B.S.8888

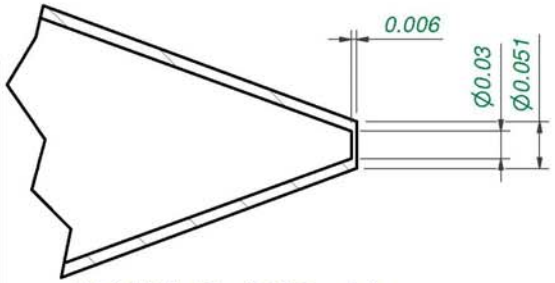




SECTION A-A (59 : 1)

ACTUAL SIZE (1 : 1)

0.500 mm THICK LINE
FOR SIZE COMPARISON



DETAIL B (200 : 1)

ISO VIEW (10 : 1)

ISSUE	DATE	MODIFICATION DESCRIPTION	DRN.	CHKD.	APPD.	STATUS
A	19.10.04		PB	PB		

USED ON SL-3000-470-00

C.C.L.R.C.-RUTHERFORD APPLETON LAB. OX11-0QX

TOLERANCE UNLESS STATED	FINISH	ORIGINAL SCALE
± 0.001	CLEAN REMOVE ALL BURRS	1:1 DO NOT SCALE
MATERIAL & SPEC.	SURFACE FINISH um	
GOLD	3.2 ✓ UNLESS STATED	0 — 50 mm

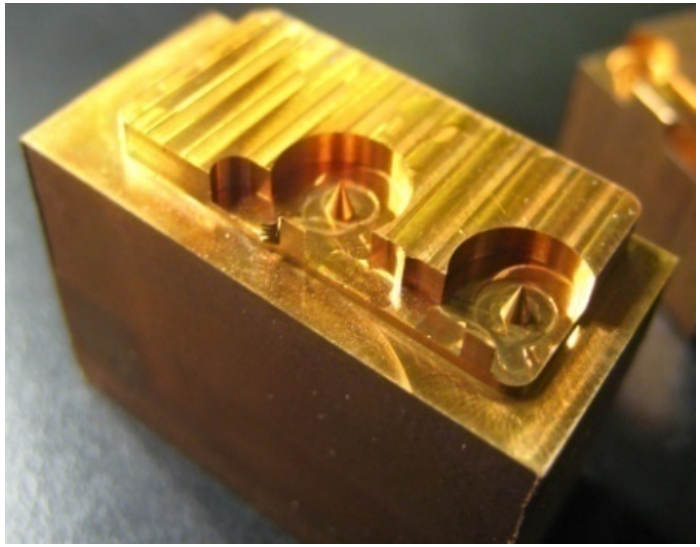
TITLE

GOLD CONE TARGET (FLAT END)

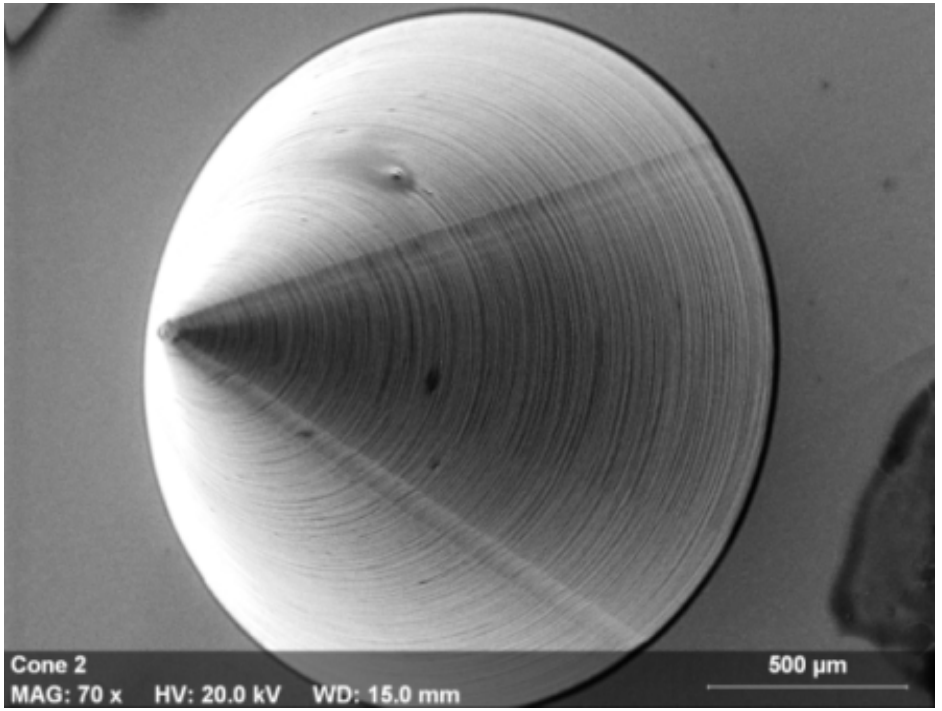
A3 | SL-3000-472-00 | REV A

SL-3000-472-00 | A3

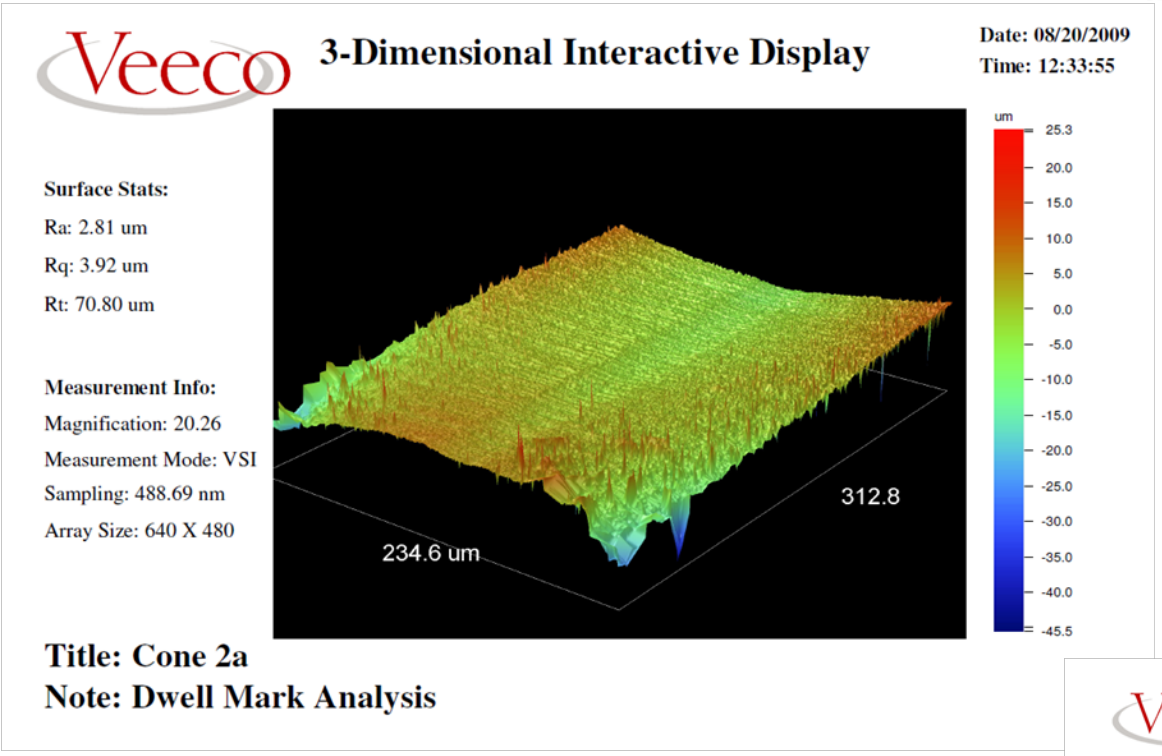
CNC Milling Feasibility

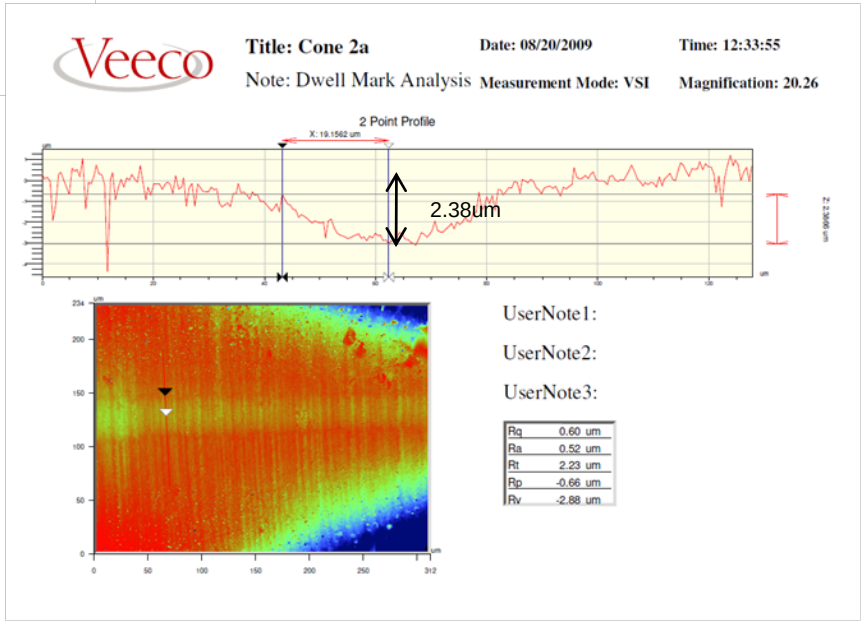


First samples machined on KERN Micro



Evidence of cutter dwell marks





Using inspection equipment available within the Laser Target Fabrication Group the depth of this dwell feature was measured to be 2.4 microns .

Enhanced development using KERN Pyramid Nano

- To enable mass production large numbers of cones need be machined in a continuous cycle.

- Using bespoke jigs and fixtures this can be extended further by having a number of blocks all set on the machine at the same time.

- In order to manufacture accurate geometries it is important to understand the performance of tooling.

Cutter Strategy development

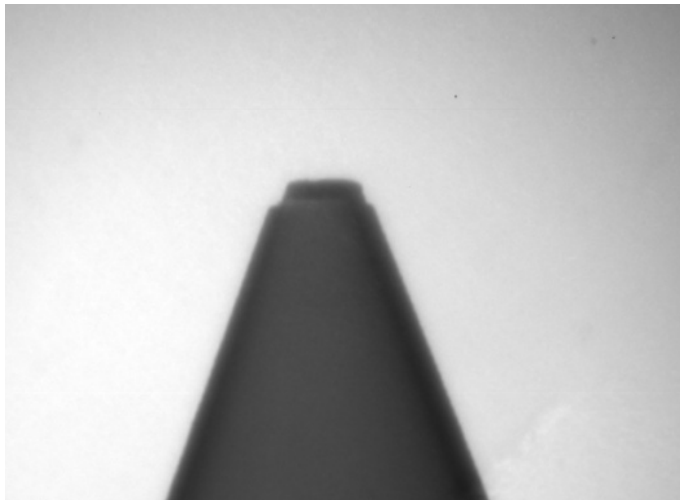
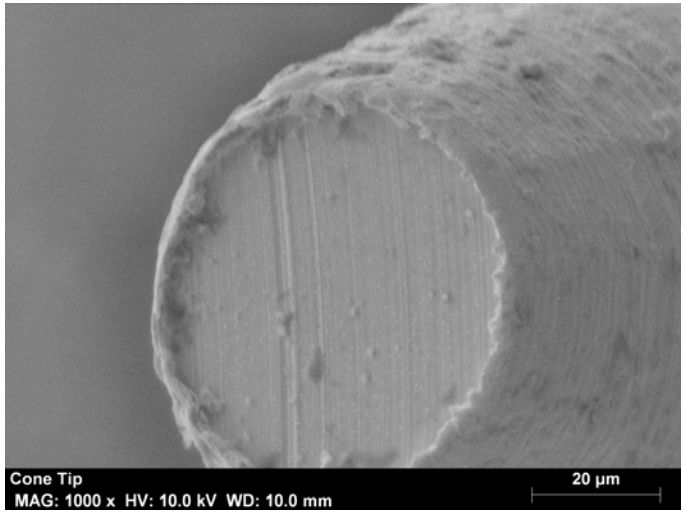


Image courtesy R.Greedharee AWE

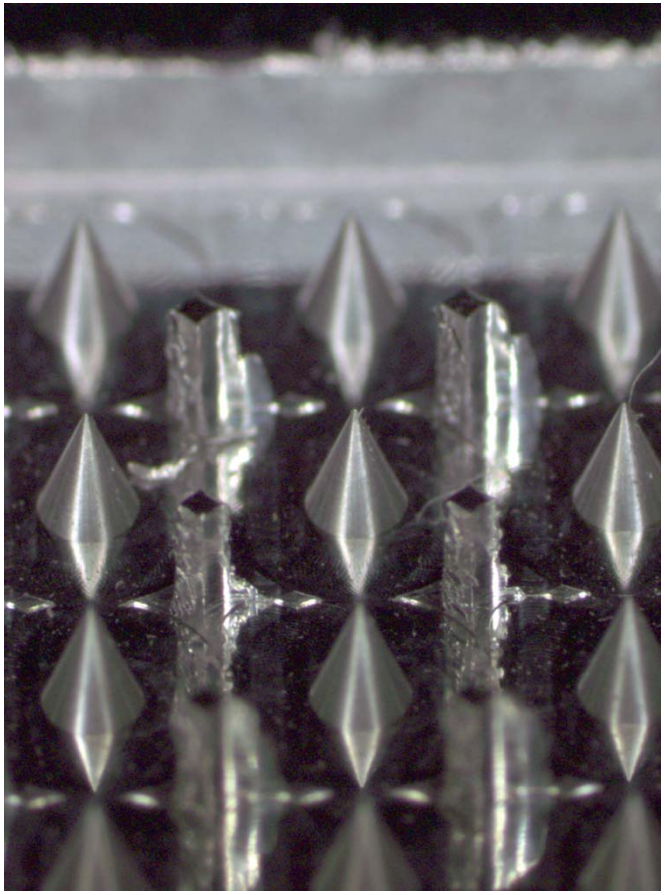


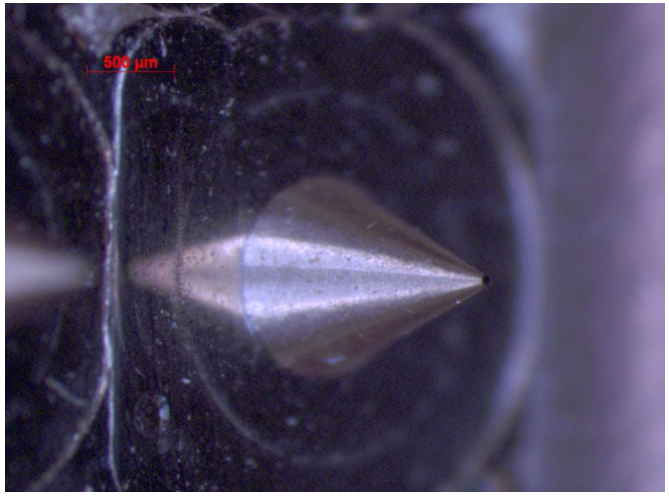
Dwell marks removed due to new machine with hydrostatic bearings and developments and refinements to tool paths.

Strategy 1
Machine all the tops to finish size followed by the machining of side walls.
Problems
Resulting cutter wear produces a step at the apex.

Strategy 2
Machine top surface of cones flat
Followed by machining of sidewalls
Problems
Burring on top face of cone

Mass manufacture





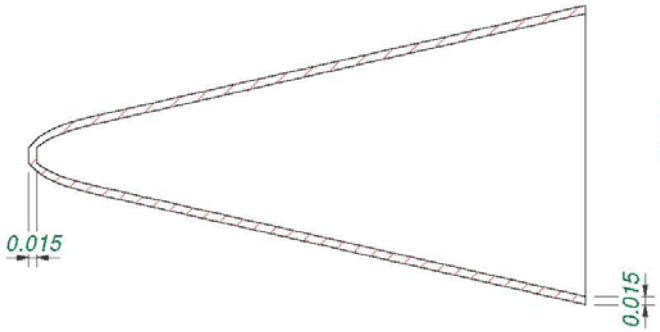
- Using modular jigs and fixtures a single block can be machined featuring ~ 50 cones.
- This is then gold plated and returned to the machine to have the external profile formed.
- The final phase is to etch off the cones.
- Nominally each machining cycle lasts 46hrs.

A3 | Parabolic Cone

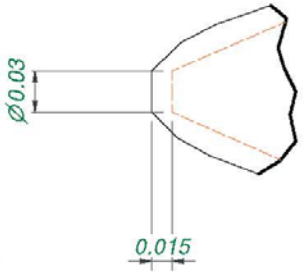
PROJECTION

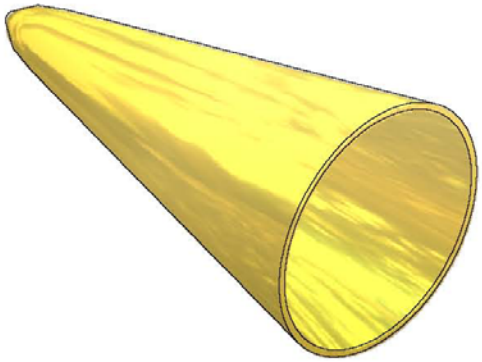
THIS DRAWING CONFORMS TO B.S.8888

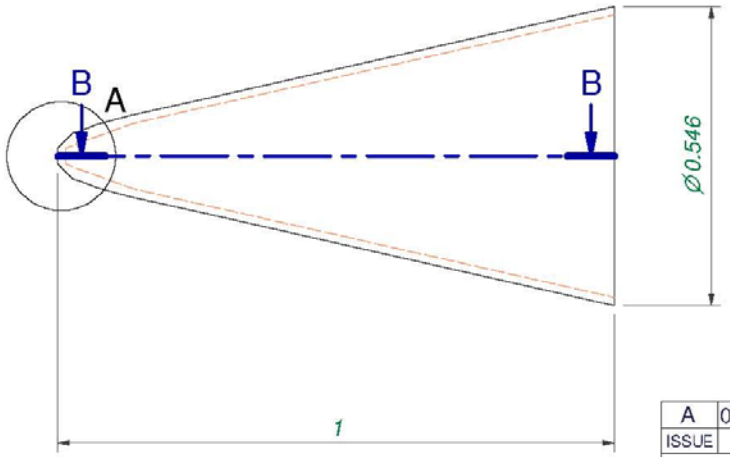
B-B (120 : 1)

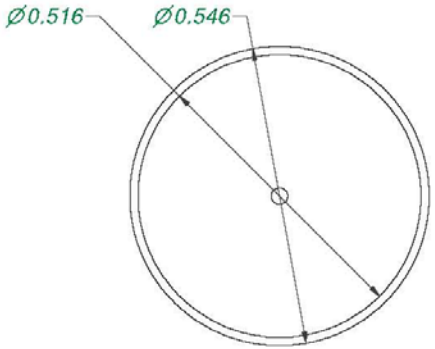


A (300 : 1)









ISSUE	DATE	MODIFICATION DESCRIPTION	DRN.	CHKD.	APPD.	STATUS
A	01/04/2009					

USED ON

S.T.F.C. - RUTHERFORD APPLETON LAB. OX11-0QX

A3 Parabolic Cone

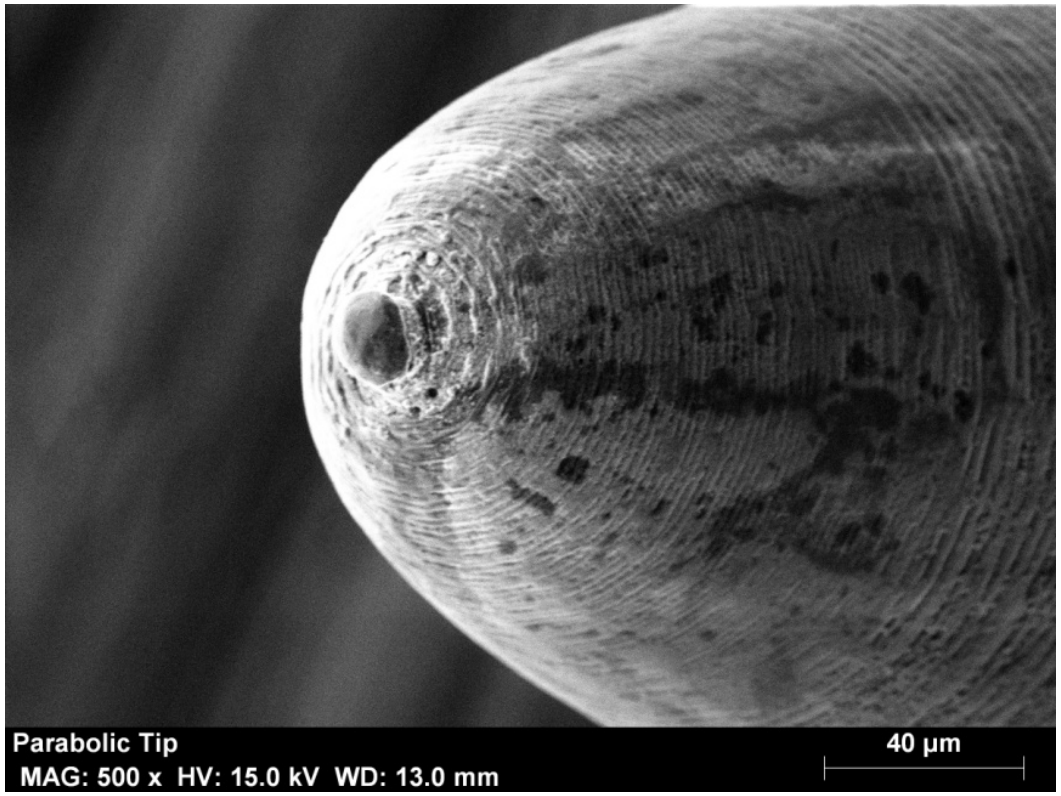
TOLERANCE UNLESS STATED	FINISH	ORIGINAL SCALE
± 0.1	CLEAN REMOVE ALL BURRS	DO NOT SCALE
MATERIAL & SPEC.	SURFACE FINISH µm	0 mm
	1.6 ✓ UNLESS STATED	

TITLE

Parabolic Cone LLNL

A3 | Parabolic Cone | REV

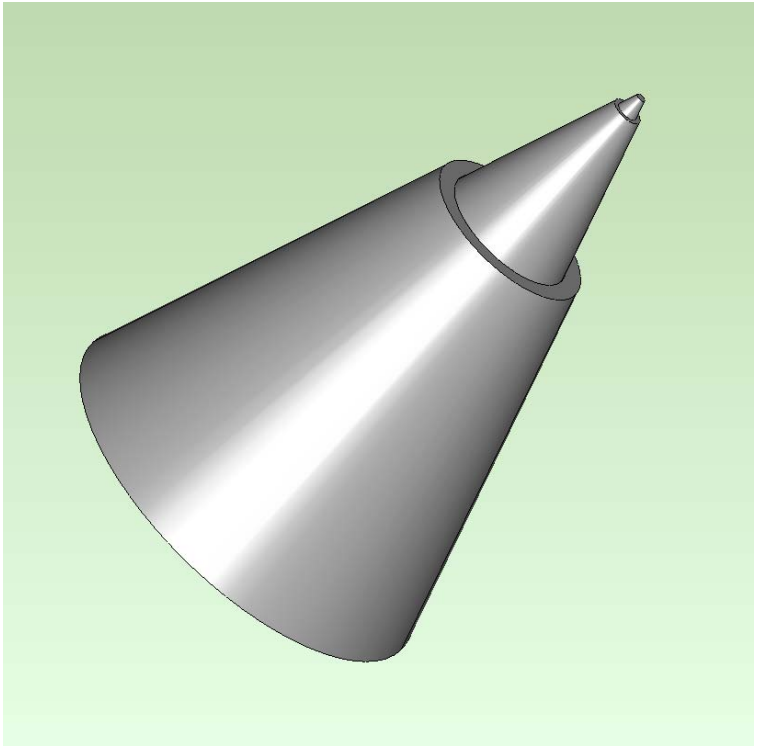
Parabolic Cone development



- The staircase effect is a result of 1 micron step over distances.
- Further down on the sidewalls this is extended to 2 microns.
- Evidence of superb positional accuracy.

Complex parabolic cones use similar machining strategies to earlier designs.
It is important than the data is correctly entered into the programme. Here the cutter path just fell short of the central axis of the cone leaving a raised section on the tip.

Future exploitation



Modelling of multilayered cones to include features 1/5th the size of a human hair!

Is this even possible?

Contact Details

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- Telephone; 01235 446562

millimetre-wave technology

MMT