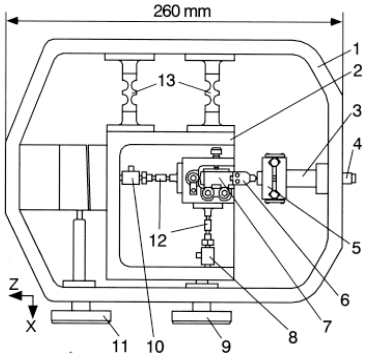
FRADPARC for Pocket Milling Machine

Functional Requirements	Design Parameters	Analysis	References	Risks	Counter Measures
1. 6axis / 3axis milling machine 2. Range X, Y = 2cm Z = 1cm 3. Tolerance = 100nm 4. Total size = 5cm by 5cm by 5cm	**Physics of operation** Subtractive : Rotating tool based machining Electrochemical milling with ultrashort voltage pulses Aditive Two photon absorptive polymerization	Modeling of machining process eg. Optimization of tool geometry for small tools Stress analysis on tools for micromachining	1. Electrochemical Machining , Philippe Allongue et al. Science Vol 289 July 2000 2. FIB shaped microtools , Picard Precision Engineering 27(2003), 59-69 3. Construction and testing of nanomachining instrument, Gao et al. Precision Engineering 24(2000) 320-328	Large range for compliant mechanism motor package size for high rpm ??	Double stage - different actuators Larger package
	Mechanics for stage Compliant mechanism based 6 DOF stage Air bearing based XY stage (size consideration ??) Pneumatic motor for compact spindle	FEM analysis First Order calculations	4. Tool geometry study in micromachining, F Z Fang et al., J. Micromech. Microeng. 13(2003) 726-731		
	Configuration Polar X riding on Y- workpiece , Bridge for Z -tool Workpiece fixed, XYZ tool	Kinematic Models parallel Vs. serial mechanisms for XYZ stage			



1: Main frame
2: Sub-frame
3: PZT
4: Capacitance probe
5: Sample holder
6: Tool shank and tool
7: Tool holder
8: Cutting force sensor
9: Y-directional fine positioning system
10: Thrust force sensor
11: Z-directional fine positioning system
12: Force decoupling flexures
13: Main flexures

Fig. 2. Schematic of the nanomachining instrument.

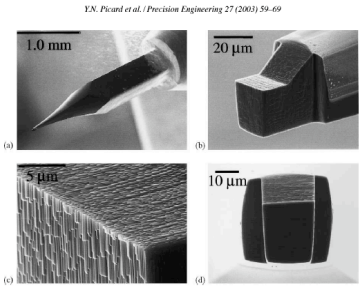


Fig. 3. (a) Low magnification view of a single crystal diamond tool shank and junction with mandrel. The tool cutting edges are fabricated on the last ~30 μm near the tip. (b) Perspective-view, high magnification scanning electron micrograph of the same diamond tool showing the FIB-shaped facets. (c) Left side cutting edge of same microtool. This image shows the intersection of three FIB-sputtered facets. (d) End view of the tool.

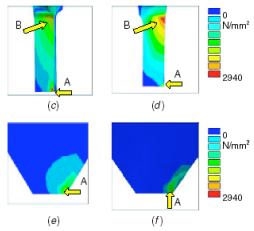


Figure 6. Simulation analysis of various tool geometries. (*a*) Calculated stress of two-flute end-mills, 0.1 mm in diameter and 0.3 mm in flute length, (*b*) zoom in analysis of (a), (*c*) calculated stress of Δ-type end-mills with straight body, 0.1 mm in diameter and 0.3 mm in body length, (*d*) calculated stress of D-type end-mills with straight body, 0.1 mm in diameter and 0.3 mm in body length, (*e*) calculated stress of Δ-type end-mills with tapered body, 0.1 mm in diameter and (*f*) calculated stress of D-type end-mills with tapered body, 0.1 mm in diameter.