Development of monocrystal Silicon Fibers by μ-Pd technique

Mauro Tonelli
Dipartimento di Fisica-Sez. INFN-Pisa-Italy

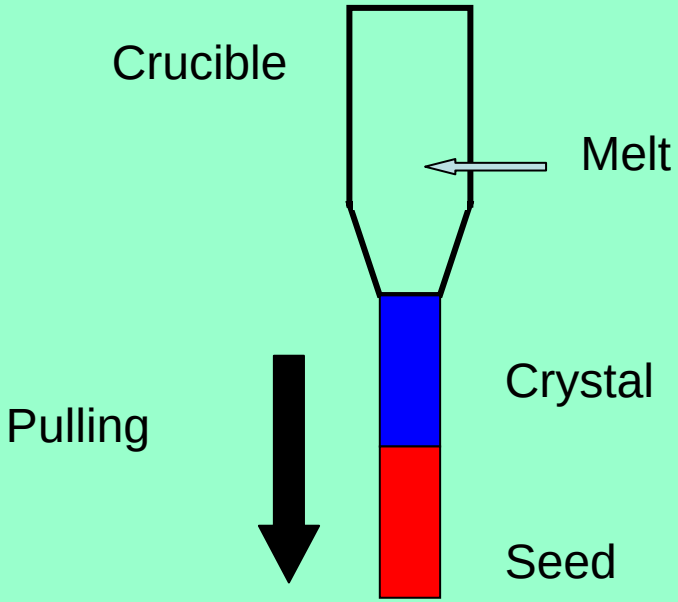
“Crystal Group” Virgo Pisa

People

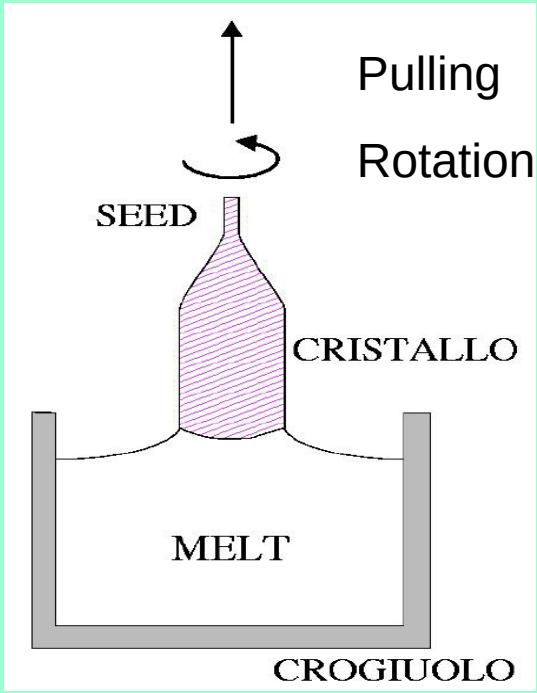
- Permanent staff: **A. Toncelli, M. Tonelli**
- Fellowship: **Zhitai Jia**

Crystal growth by melt

μ-Pulling down

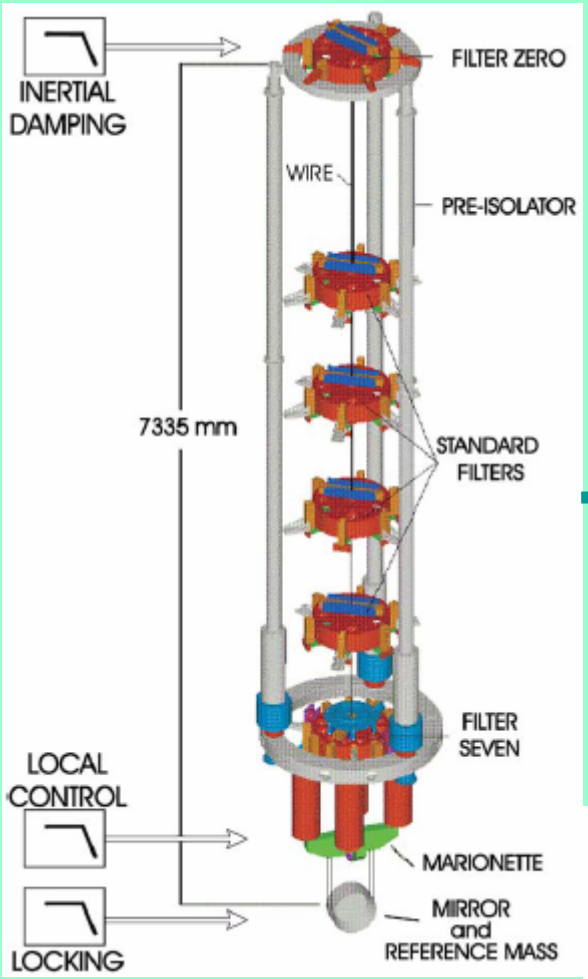


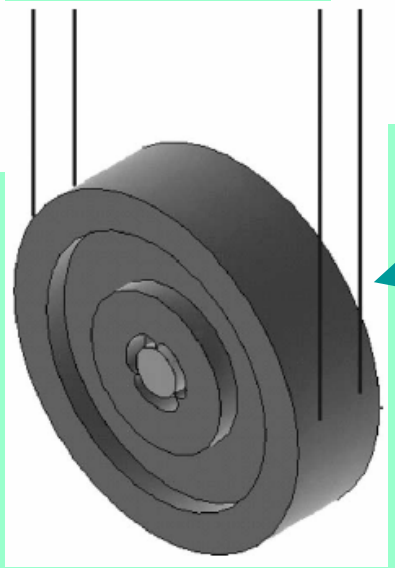
Fiber or shaped crystal

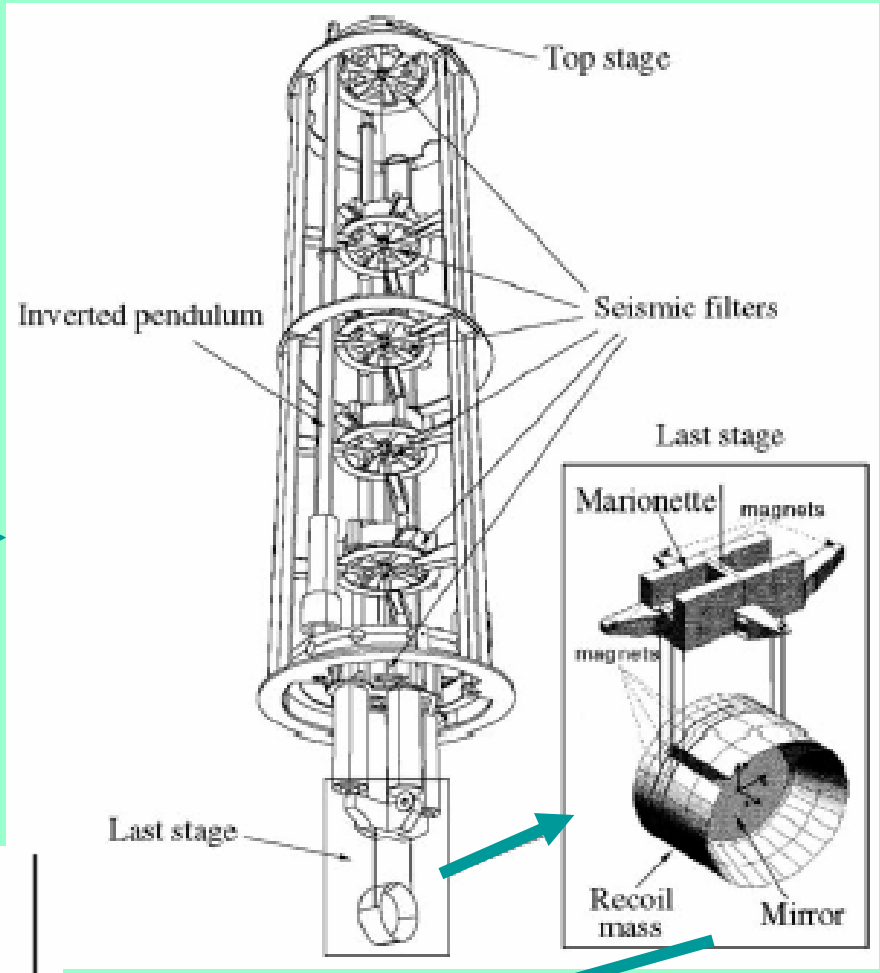


Czochralski

Crystal Rod

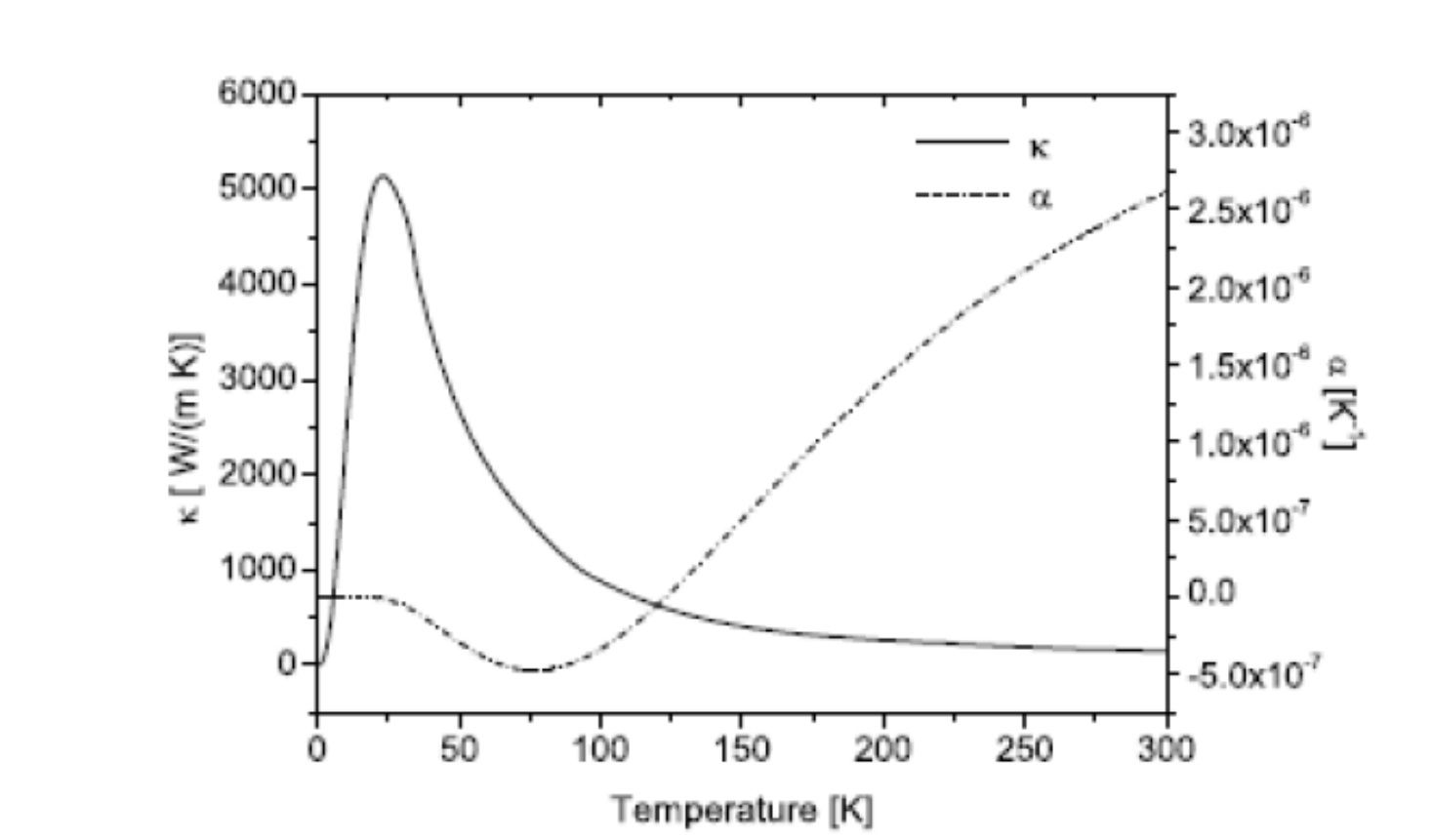






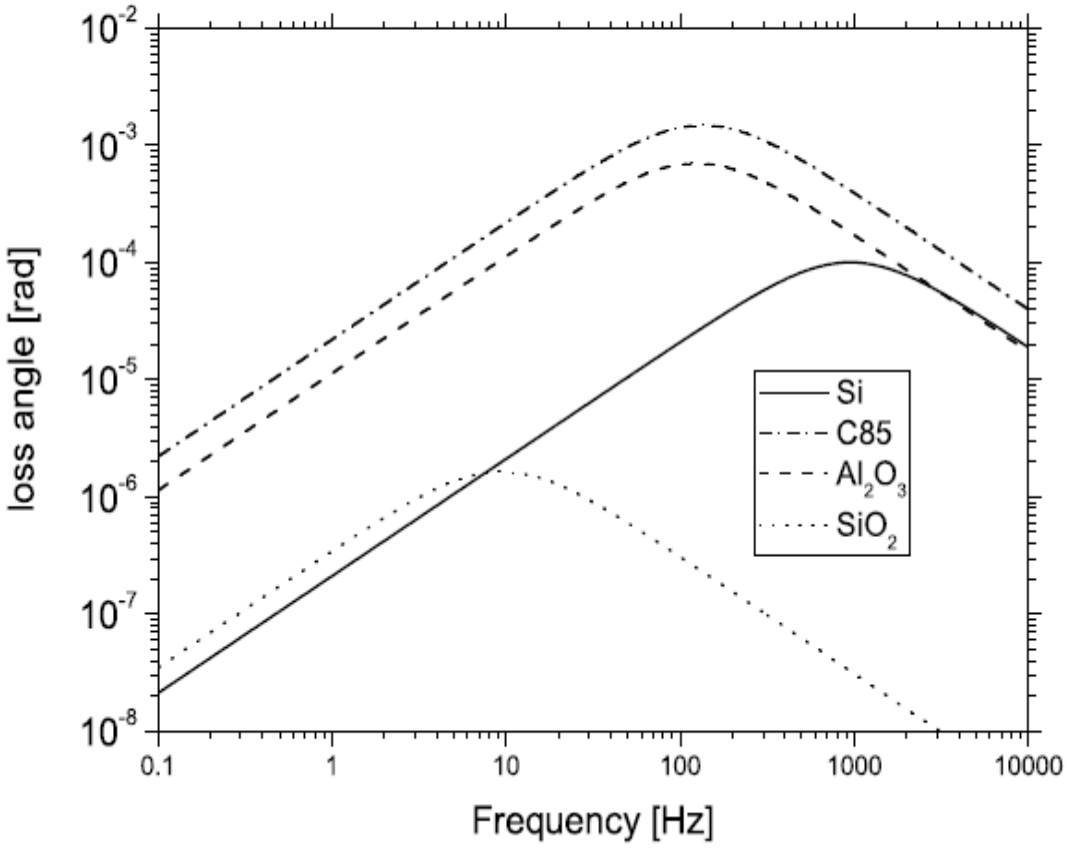
Monocrystal silicon wire

Silicon crystal physical characteristics



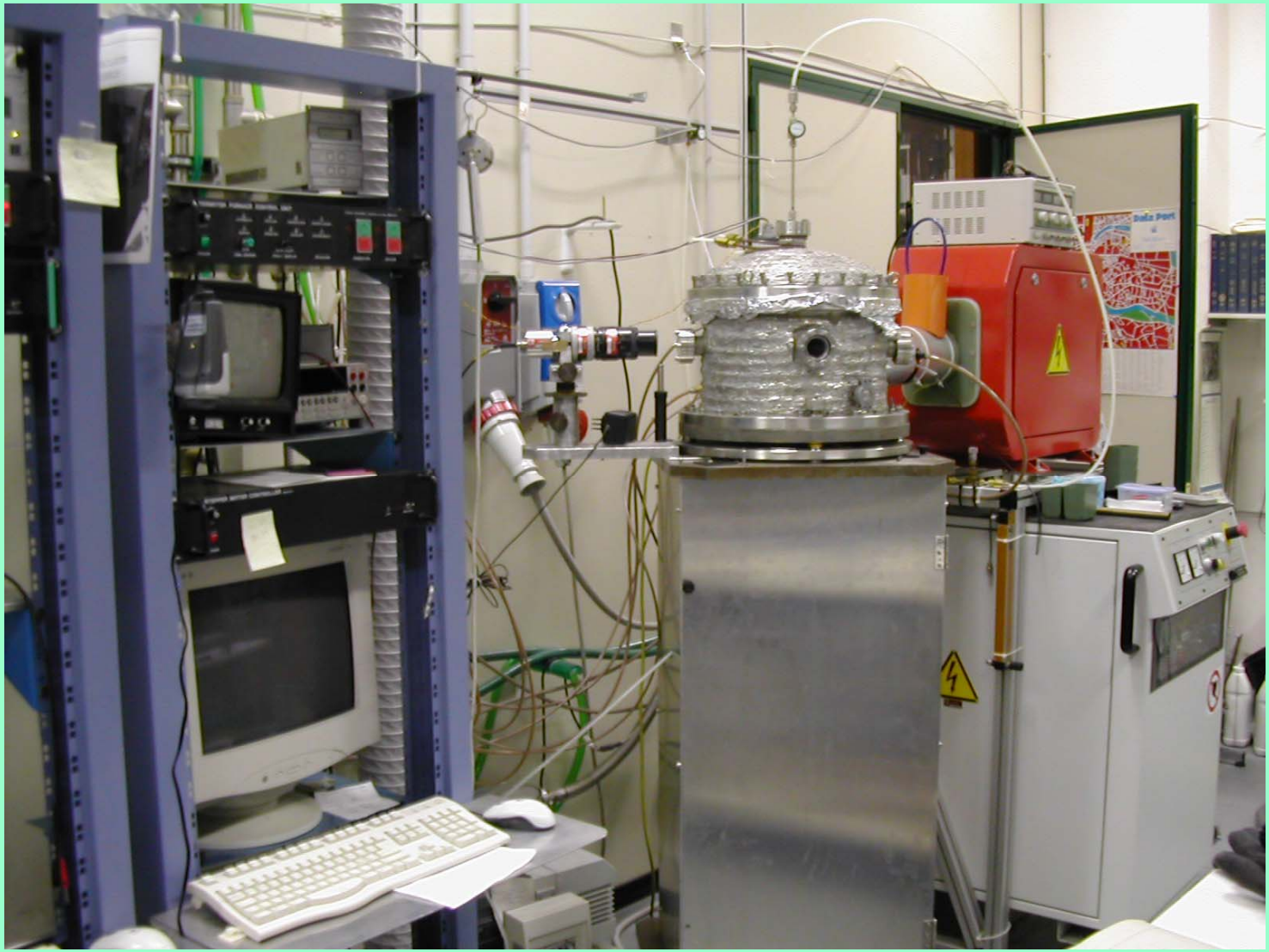
Linear thermal expansion coefficient and Thermal conductivity

Crystal Silicon loss angles

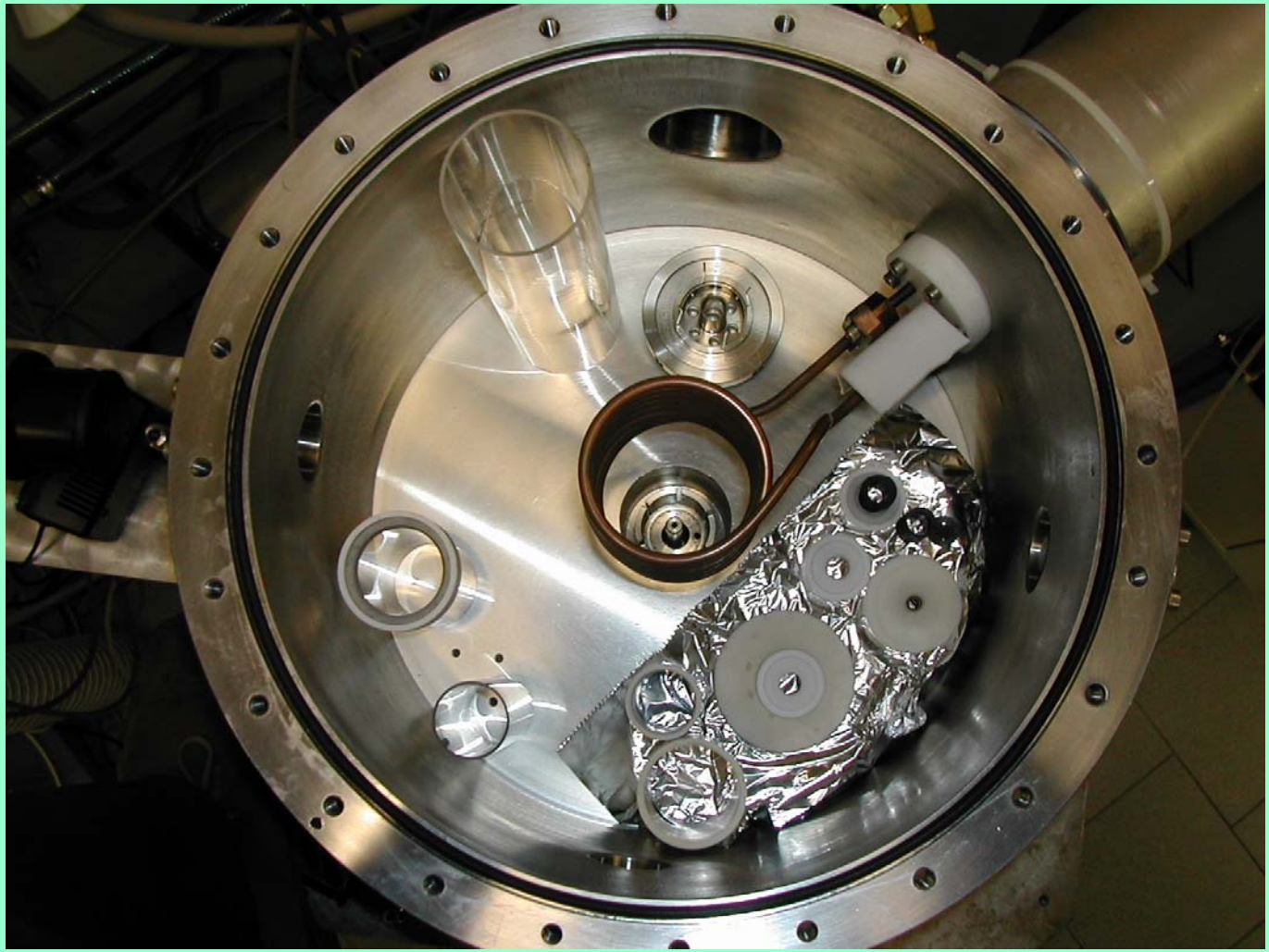


Thermo-elastic loss angles for different materials

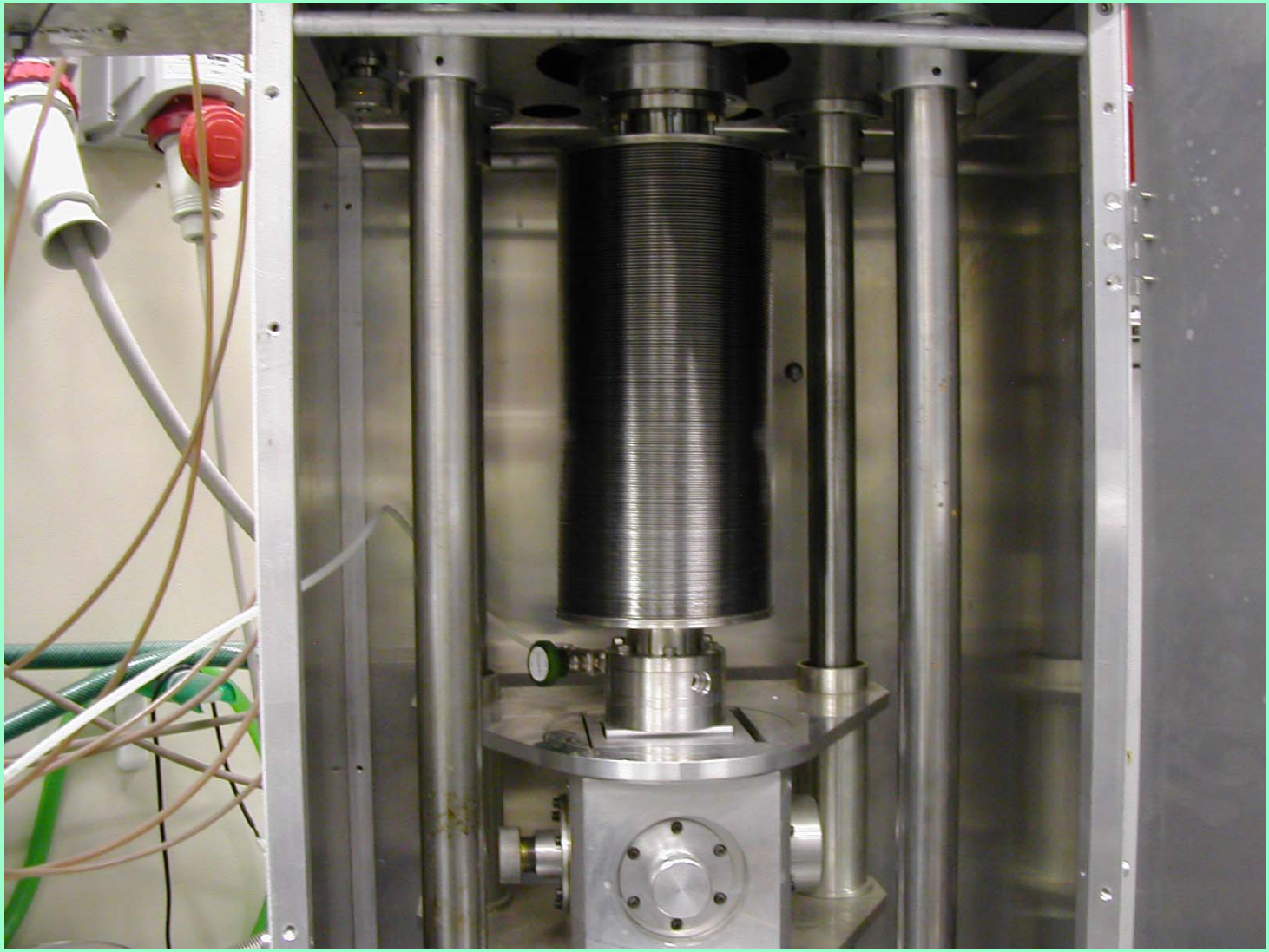
μ-Pd Structure



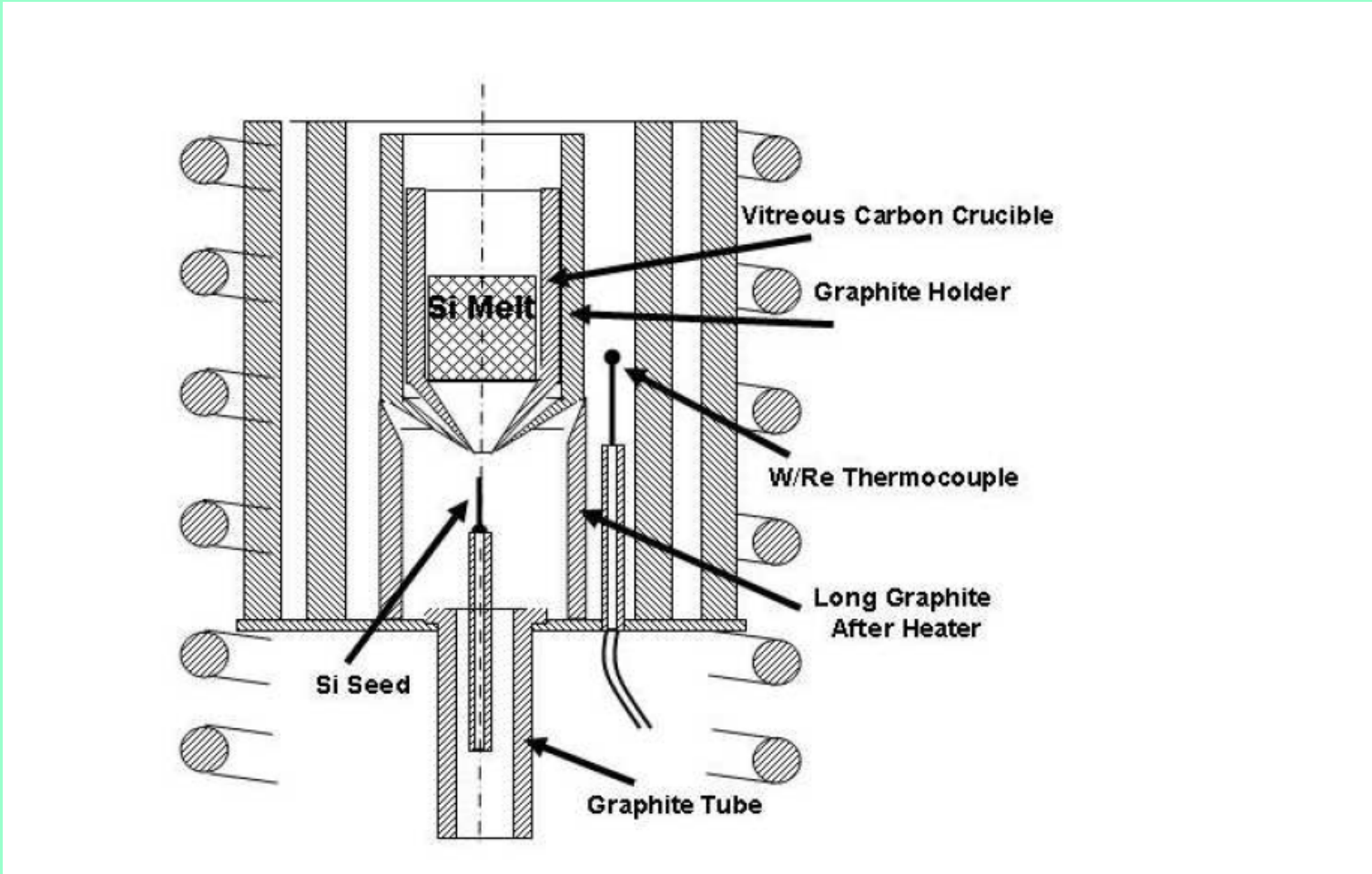
View inside the furnace



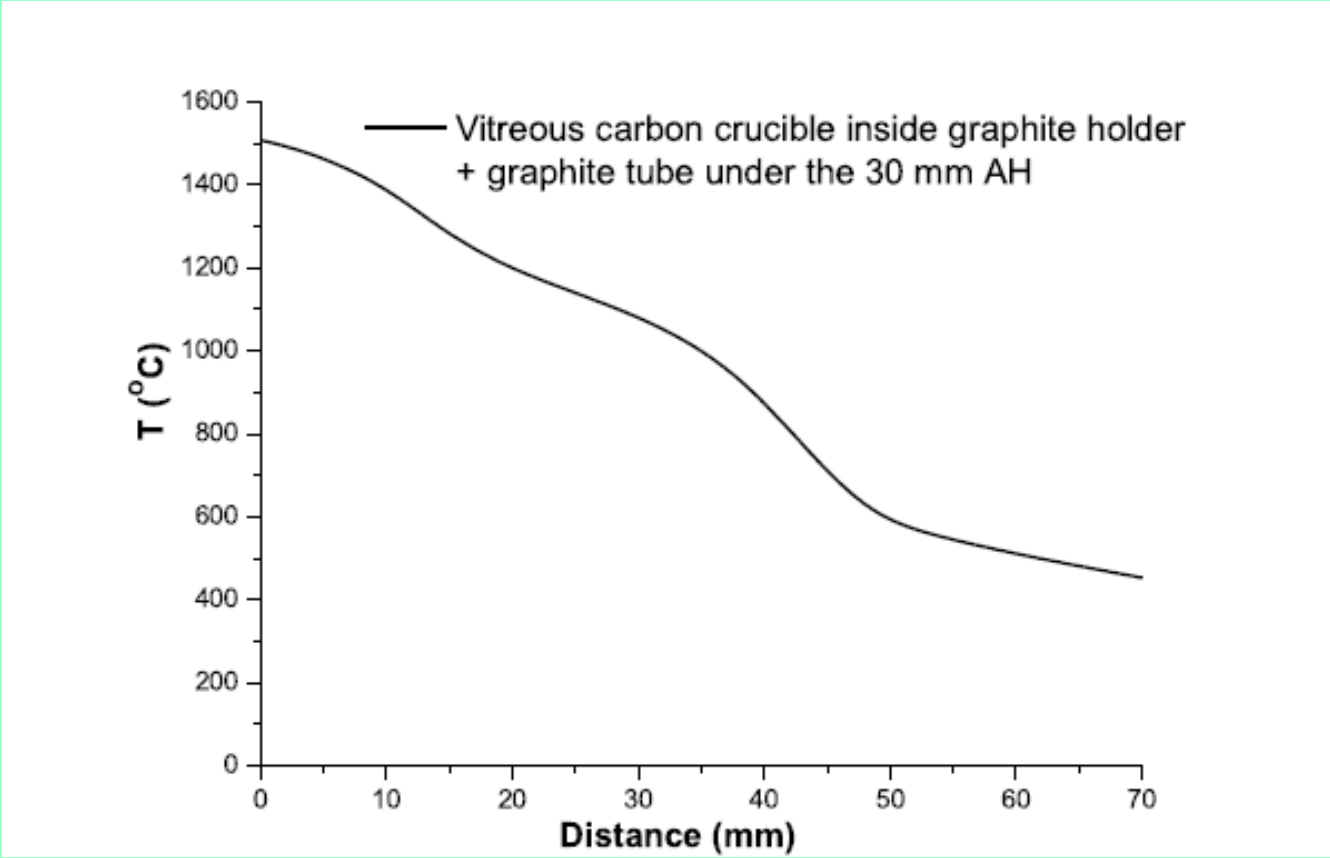
Pulling Structure



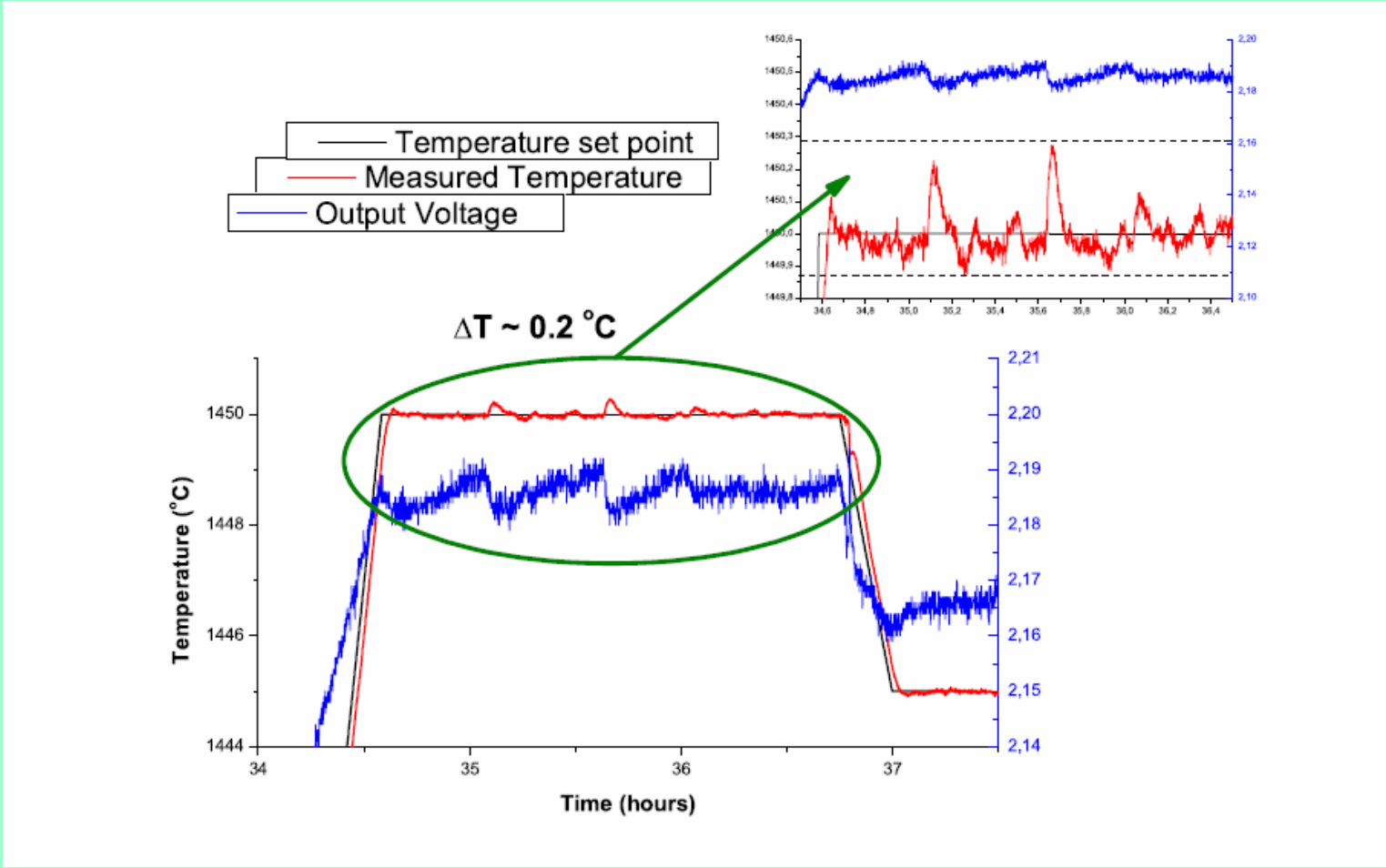
Crucible Assembly



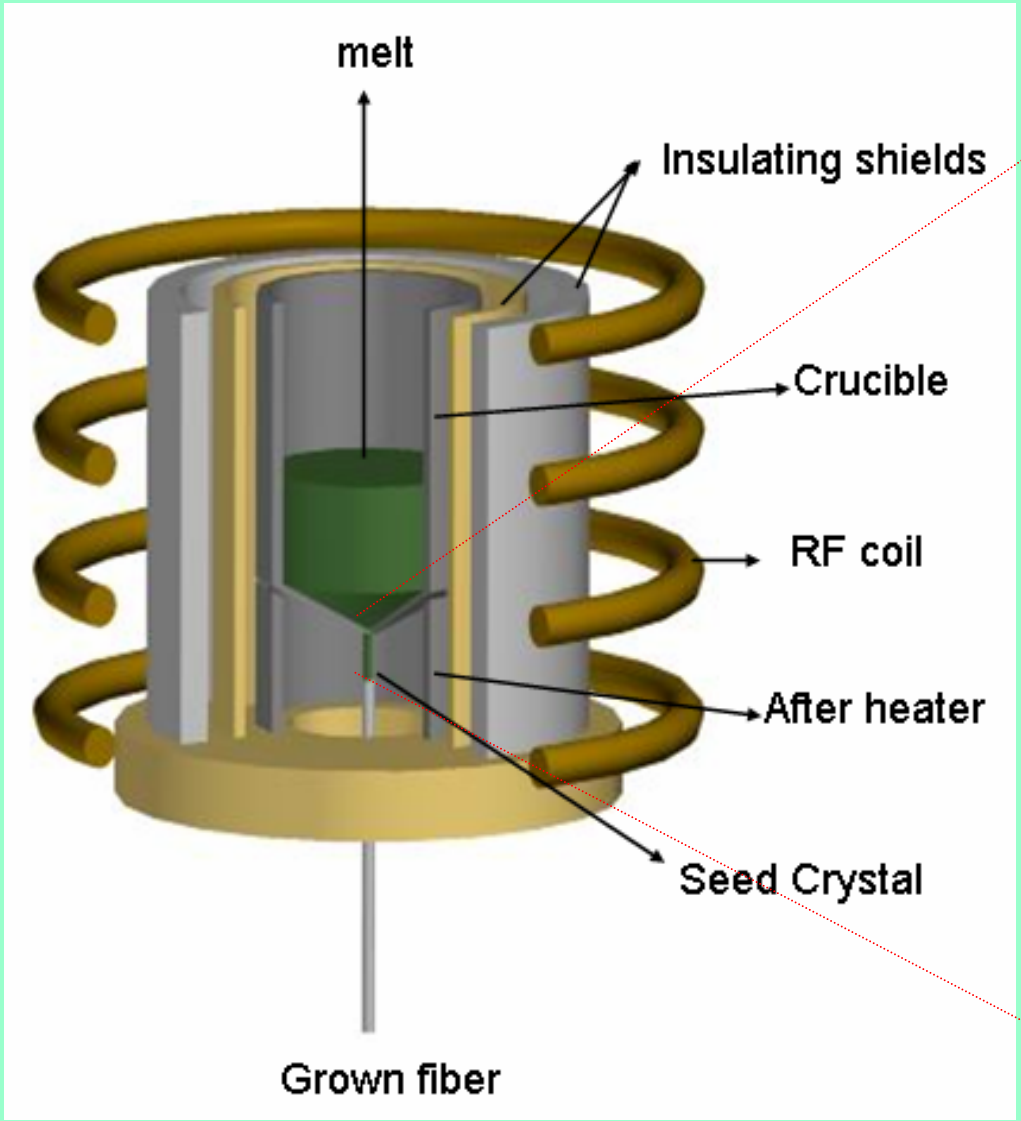
Temperature profile

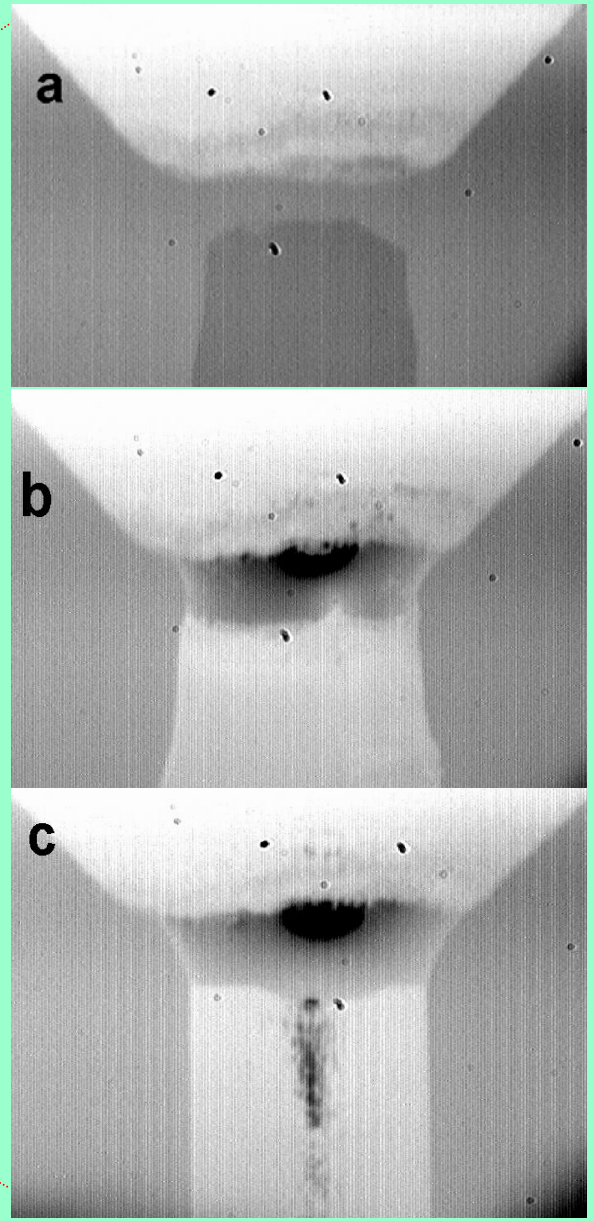


Temperature stability

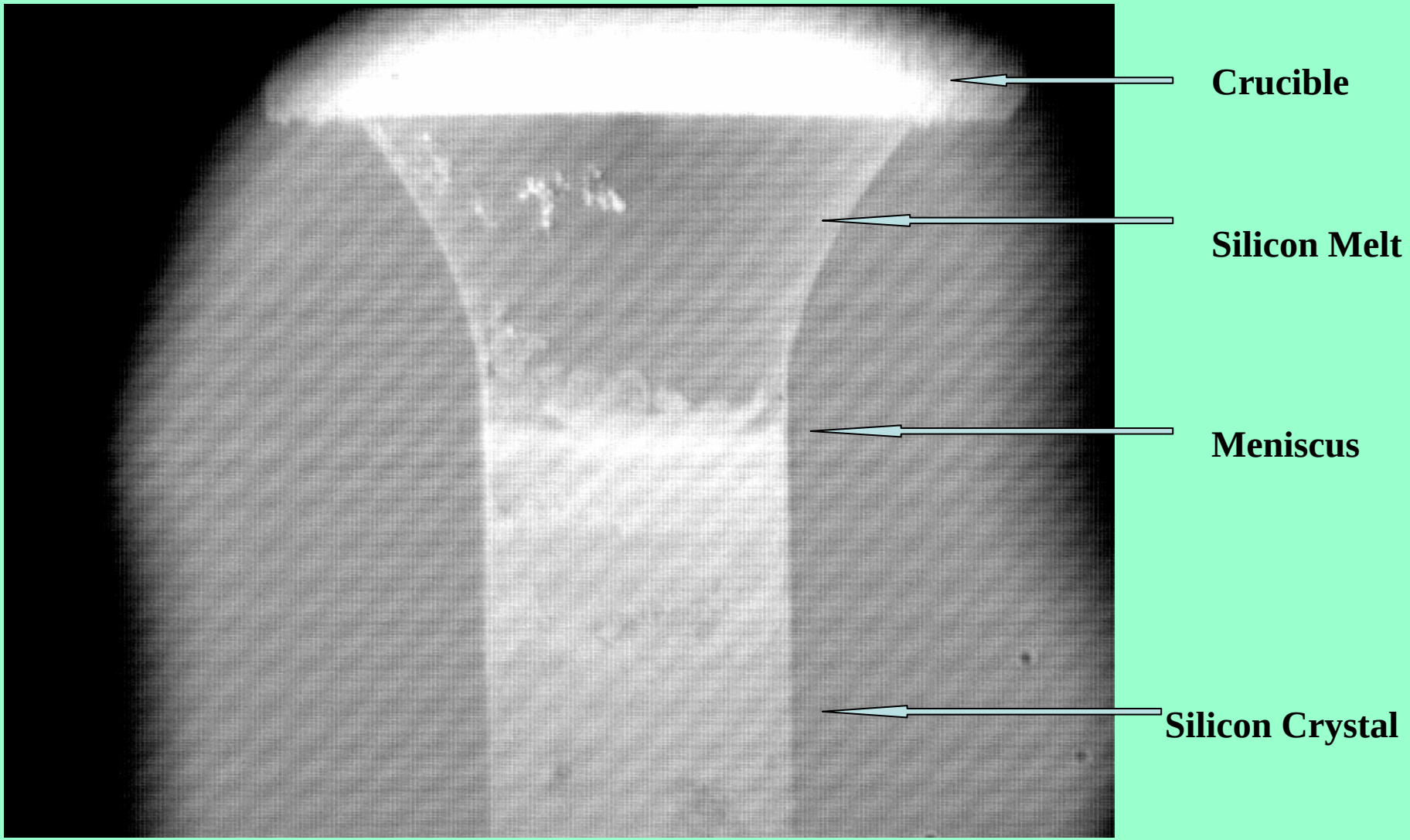


Schematic of micro-PD method





Fiber growth



Capillary stability

Silicon <111> ϕ_o= 11°

$$dR/dt = v\tan(\phi - \phi_o) \neq 0$$

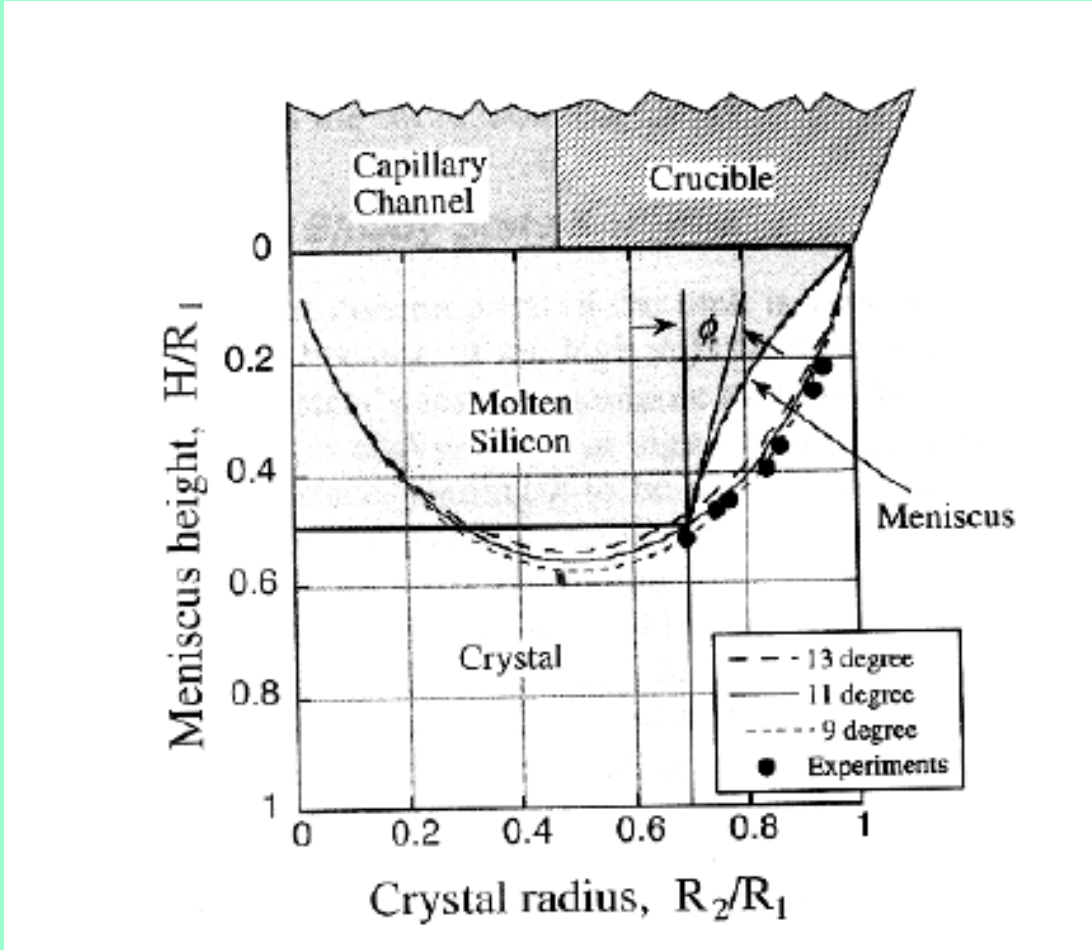
v = pulling rate

Capillarity condition:
Bond number

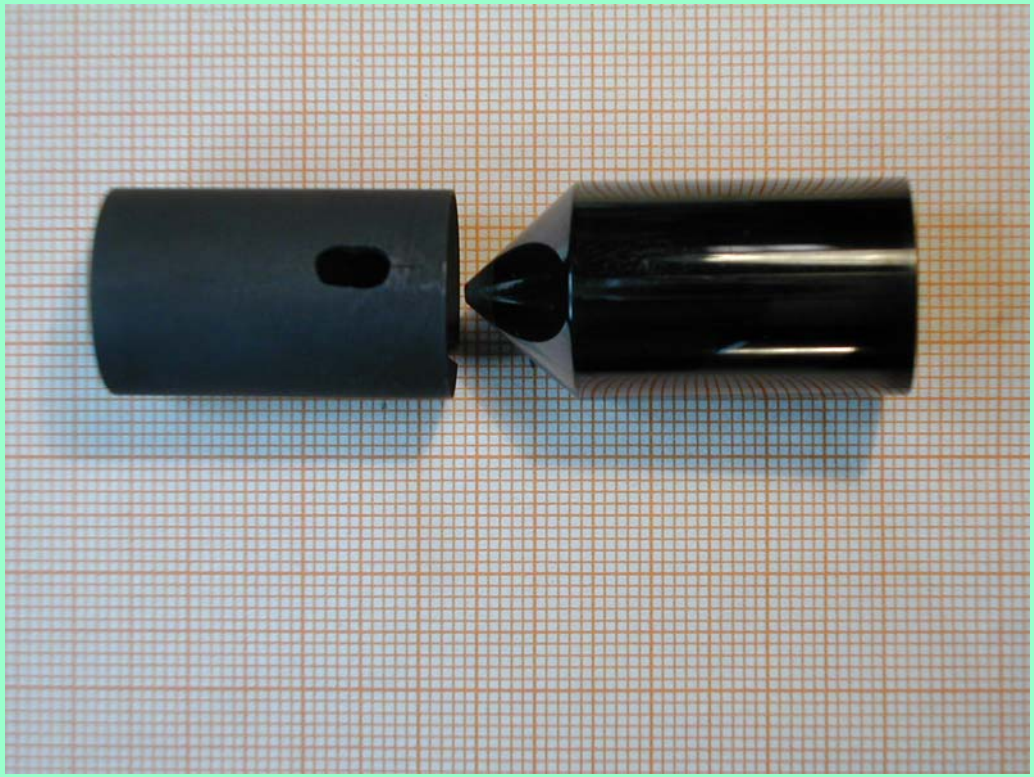
B= $\rho g d^2/4\gamma << 1$

ρ= melt density

γ= surface tension

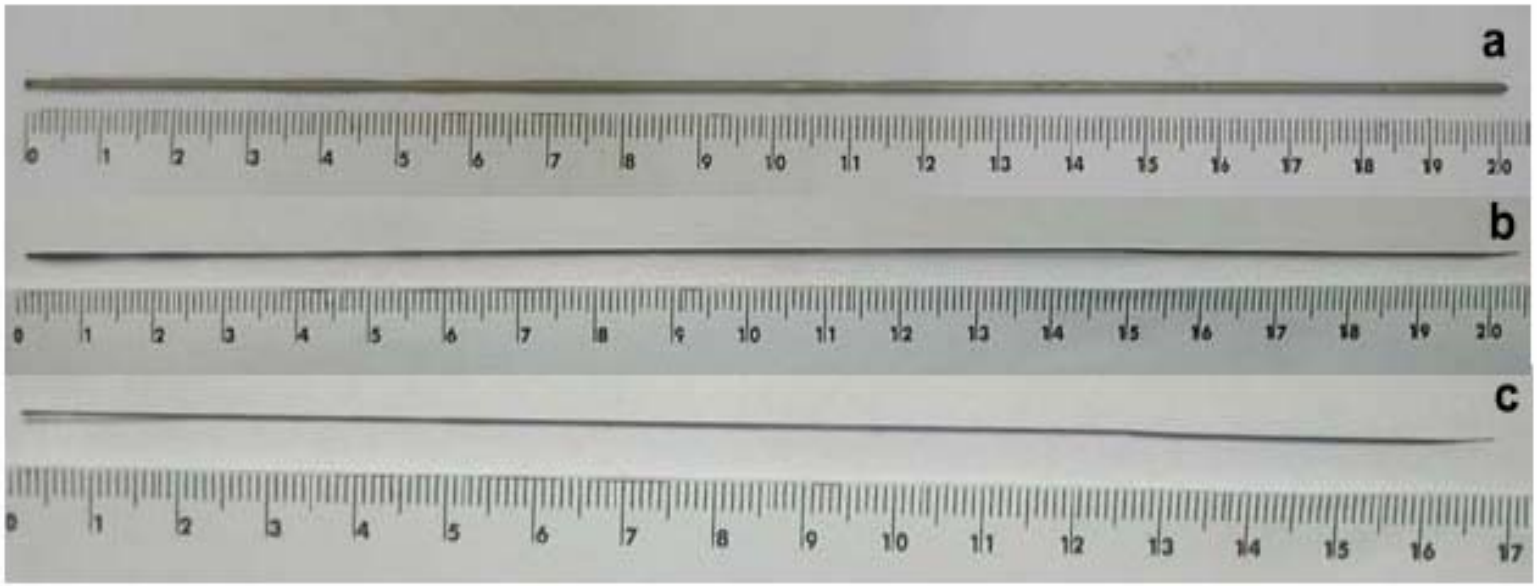


Vitreous carbon crucible



Vitreous carbon crucible and After Heater

Silicon Fiber



As-grown Si Single crystal Fibers with (a) 2.5 mm in diameter and 200 mm long; (b) 1.2 mm in diameter and 210 mm long; (c) 0.7 mm in diameter and 165 mm long

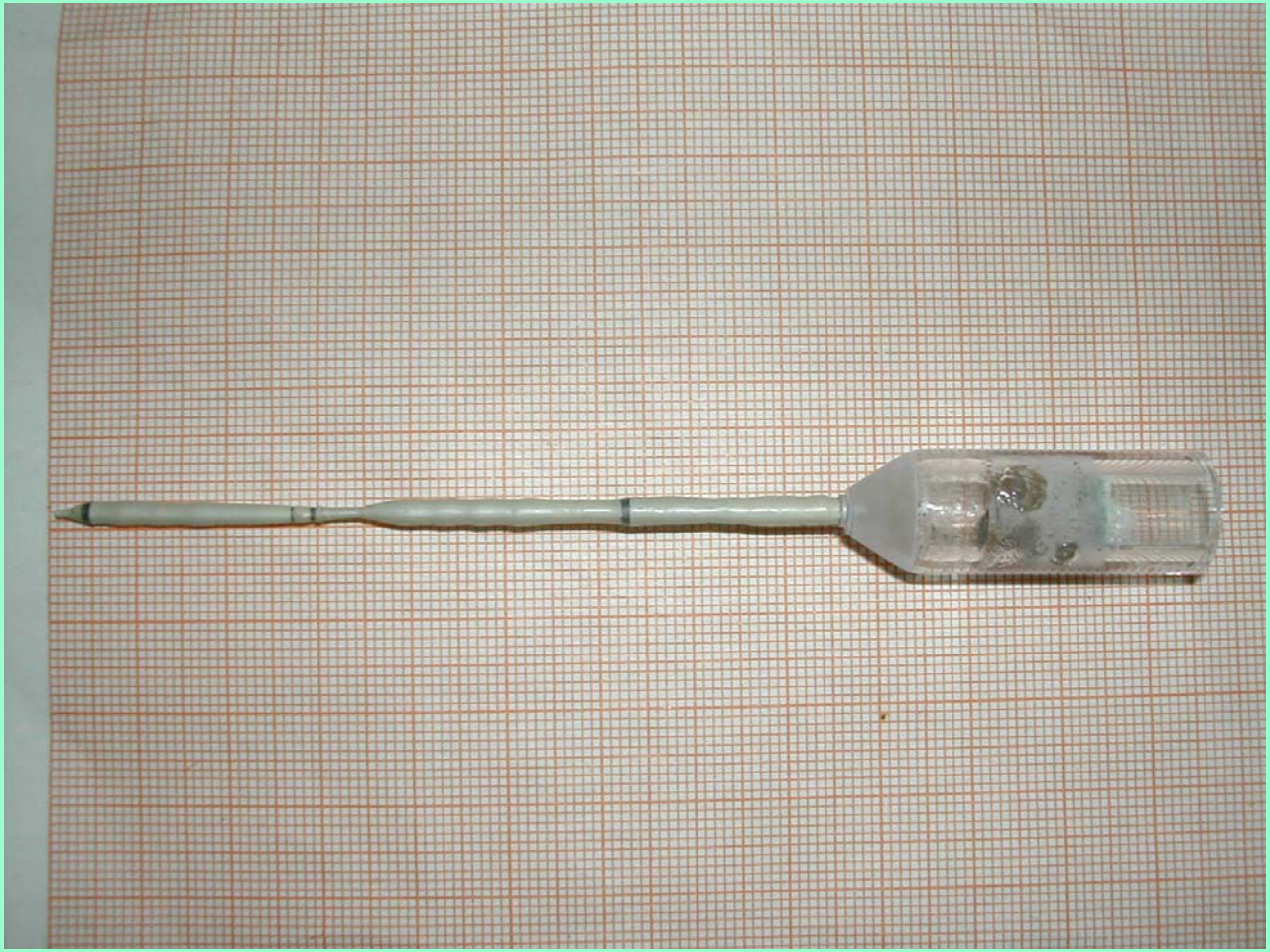
Silicon Fiber

Fiber Diameter ~ 1 mm, Length 290 mm

Silica crucible

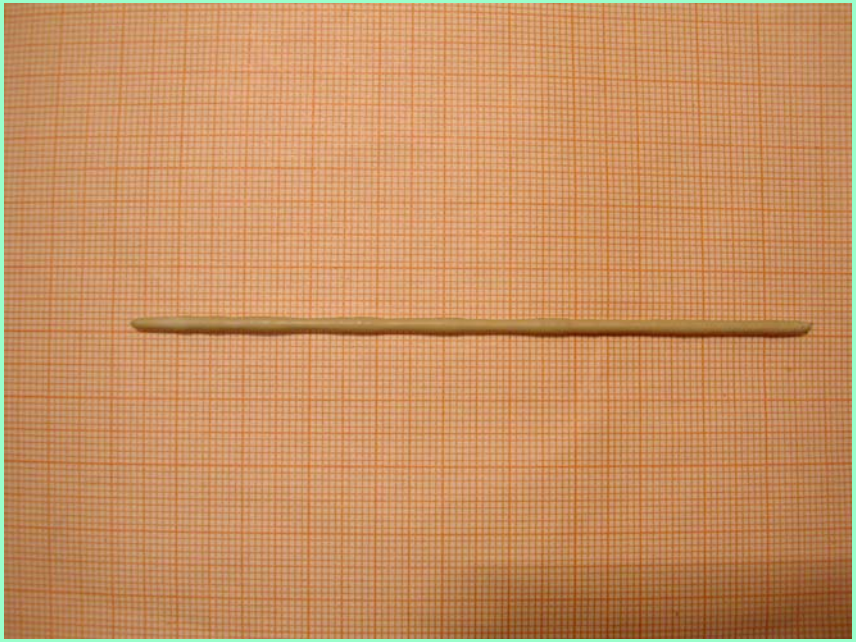
Silica (HQ45) and Special graphite heater

Crucible and silicon fiber

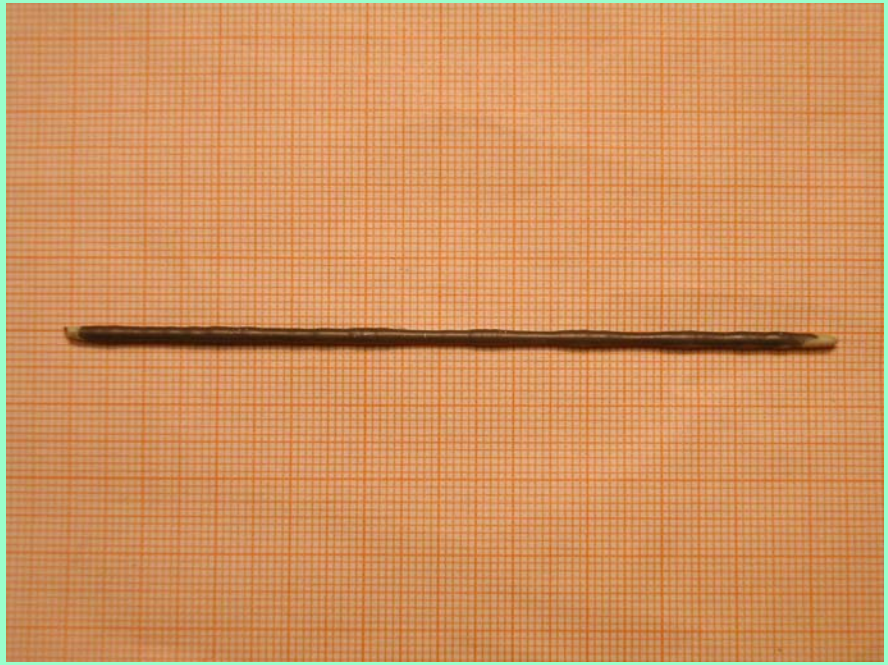


Fiber as grown and Silica Crucible

Silicon Fiber

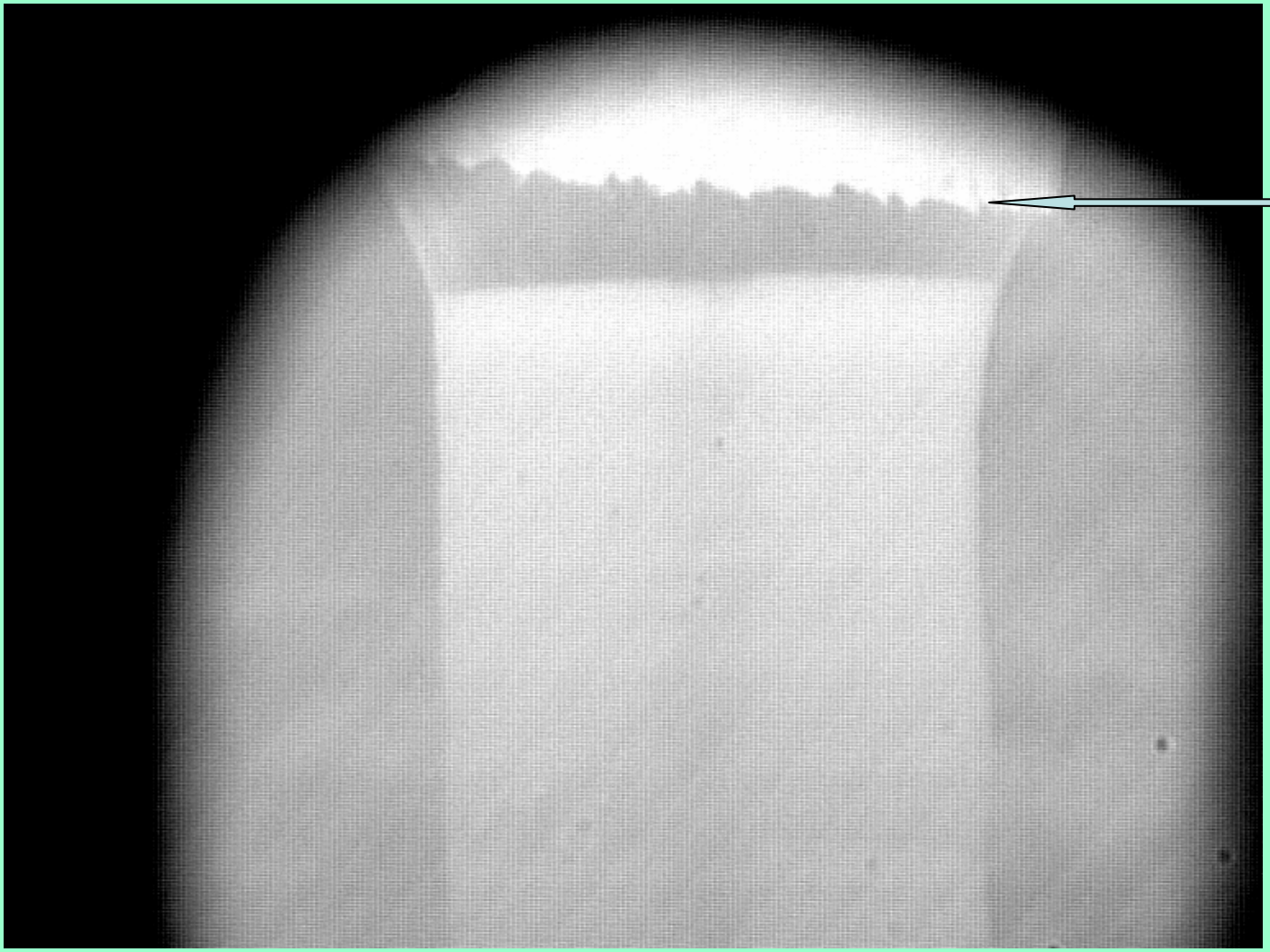


Fiber As grown

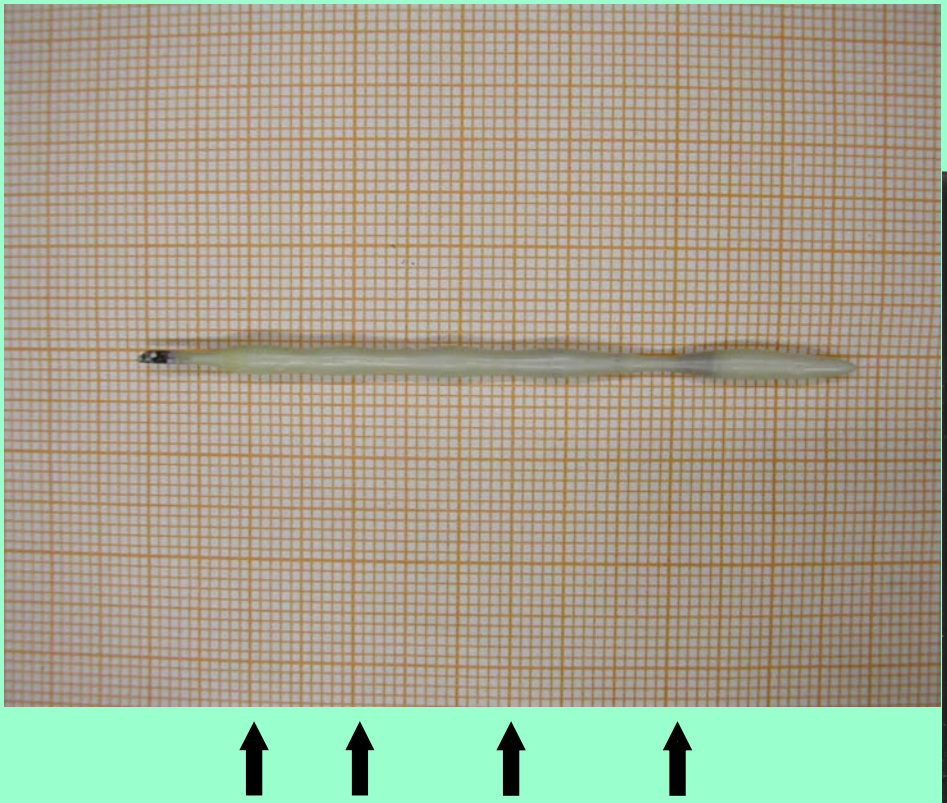


Fiber Clean

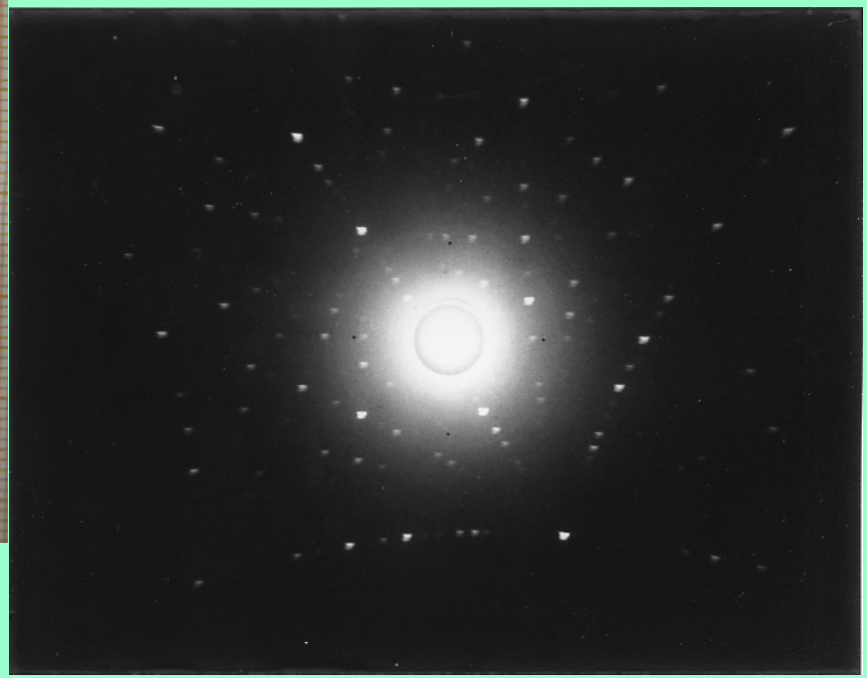
Fiber Growth



RX-Laue Chamber Analysis

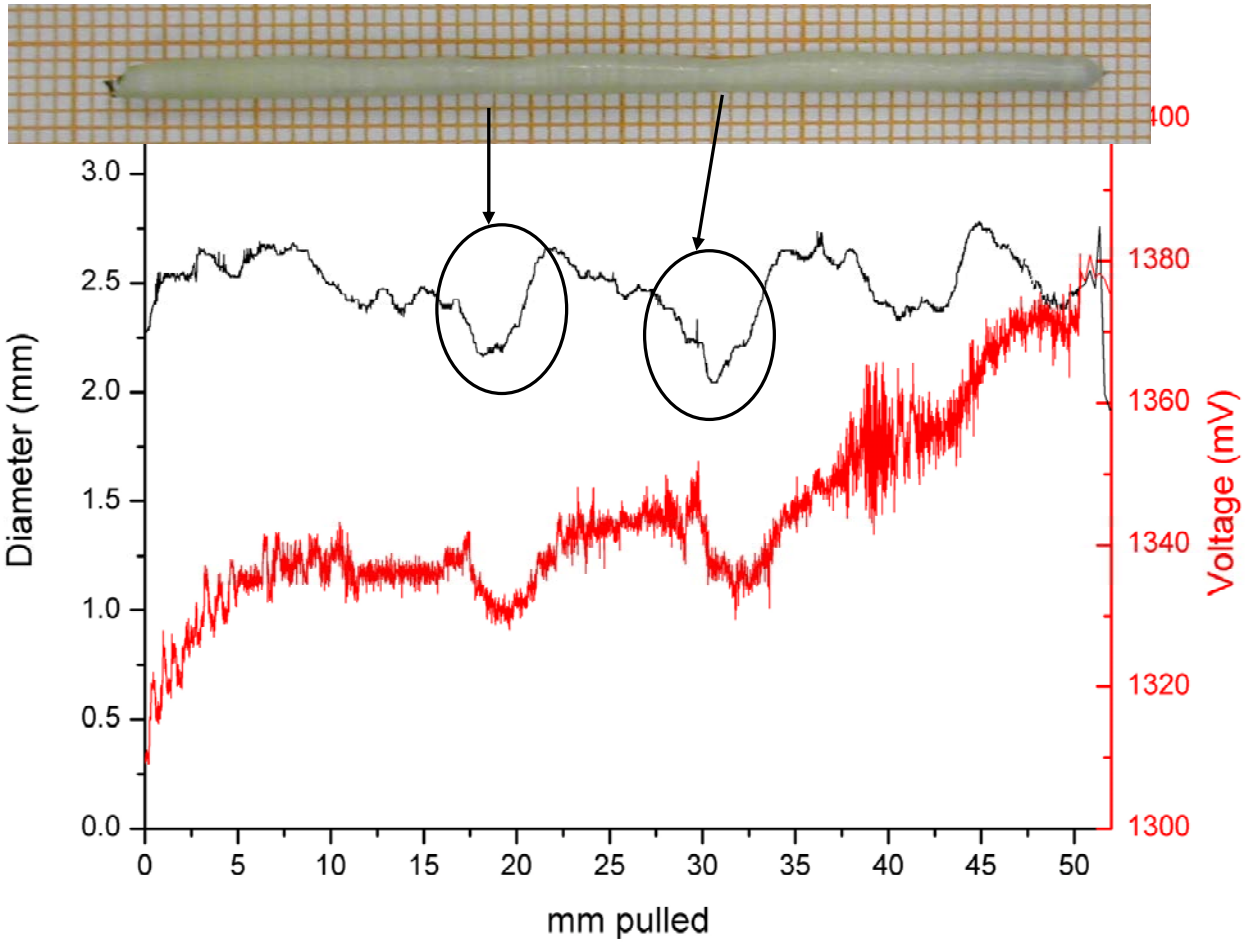


RX-Laue Chamber mesurements

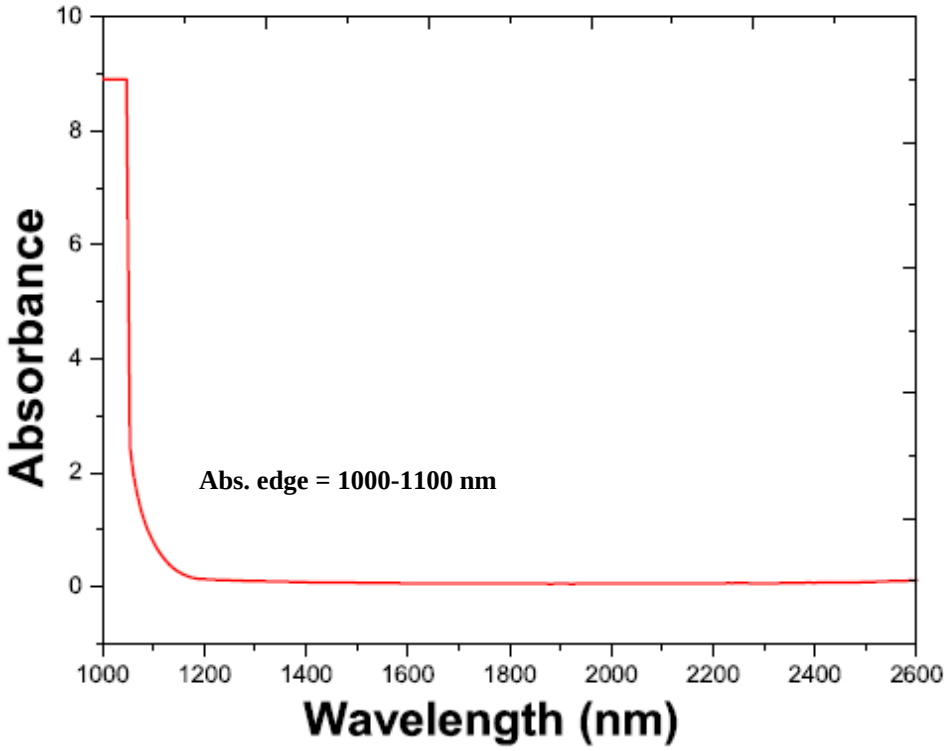


RX diffraction

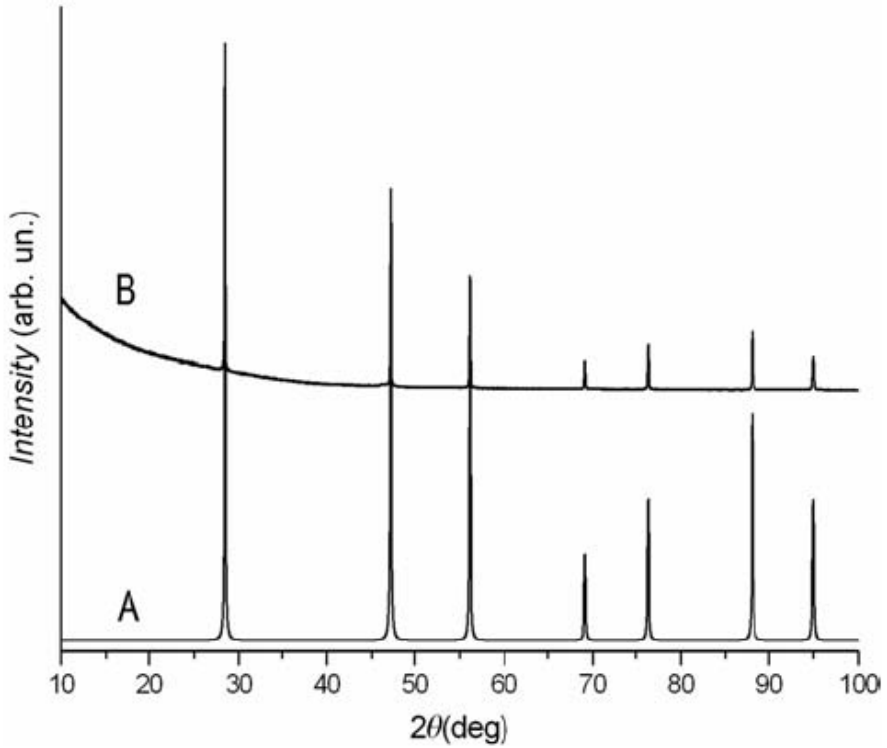
Diameter Fiber Control



Absorption Spectroscopy



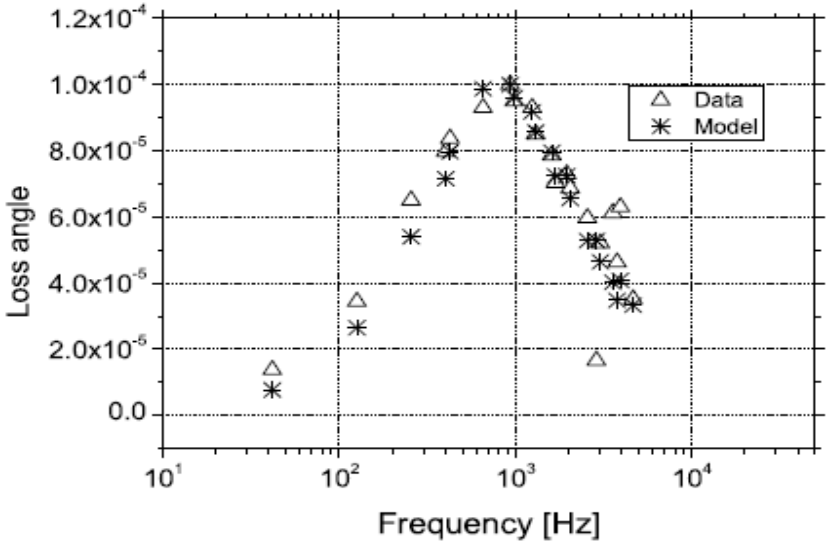
Silicon X-Ray diffraction



Experimental

calculated

Preliminary measurements of loss angle



Problems:

- **diameter fluctuation (~10%)**
- **flip crystal axis orientation (impurities problems)**
- **clamp problems=chemical bond**

Future work

- **Improvement fiber growth**

- **New SiC crucible**

(no chemical reaction with Silicon)

- **FZ Crystal fiber method**

New growth method without crucible contact

Float Zone Fiber Crystal Growth