Laser dressing of tools

SSOM Engelberg Lectures on Optics

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Grinding

stock removal grinding

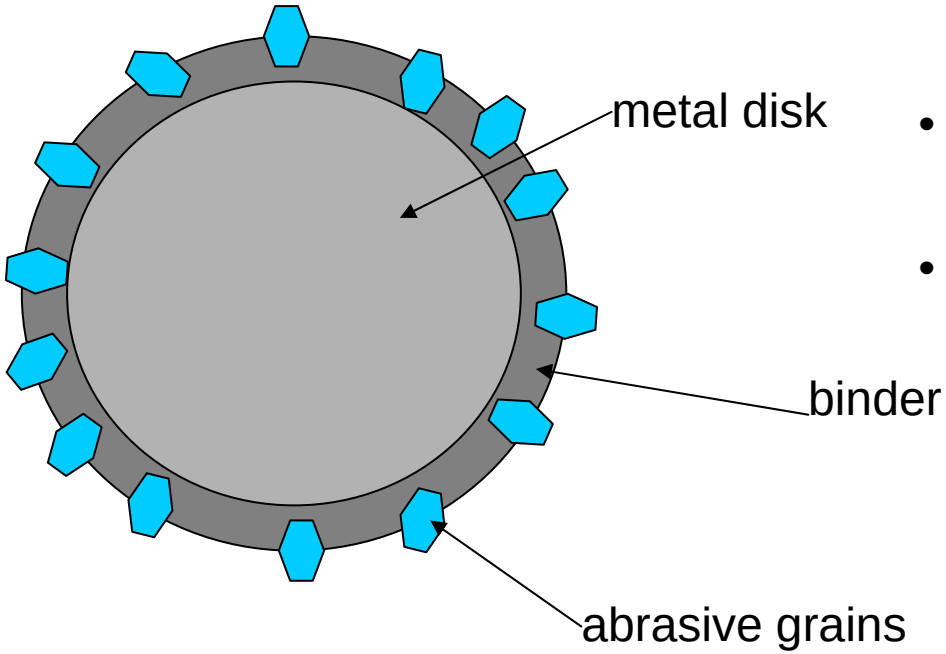
- rough grinding
- high ablation rates
- rough surface

precision grinding

- finish grinding
- smooth surface
- high quality
- low tolerances

Schematic of grinding wheel

grinding wheel



goals

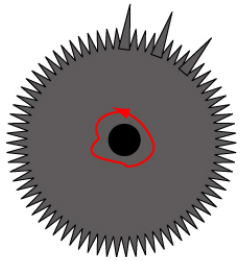
- long wear time
- high ablation rate
- high precision

important parameters

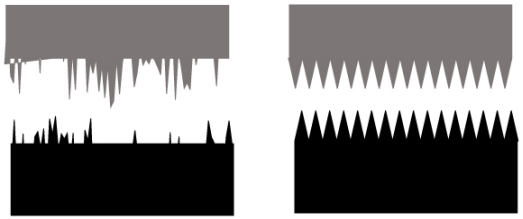
- grain material
  Al_2O_3, cBN, SiC, diamond
- binder
  resin, metal, vitrified, organic
- grain density
- surface roughness
- grain size

Why dressing?

- reduction of vibration



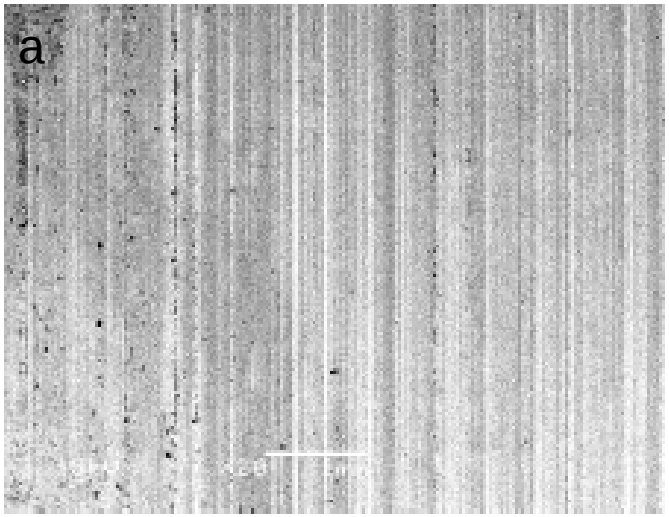
- improved surface finish

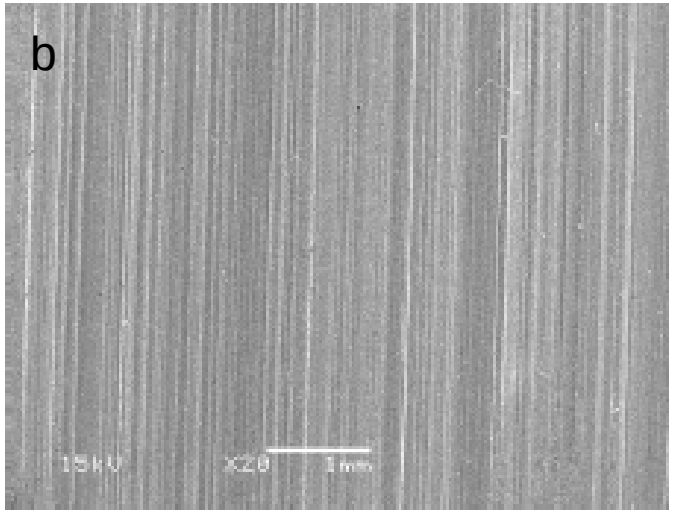


- re-sharpen cutting edges

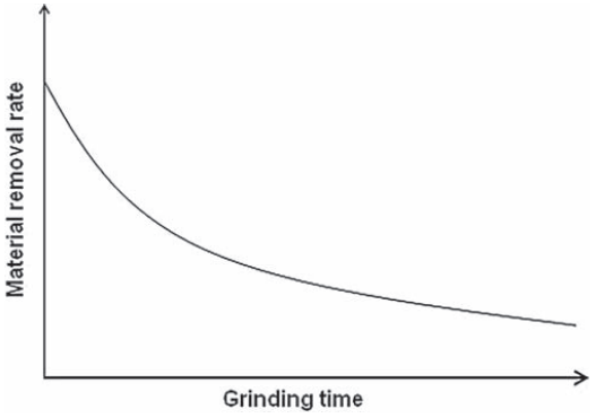
- exposing fresh grains

Wearing out of grinding tools





Surface situation after grinding: a) undressed grinding wheel, b) dressed grinding wheel
Wang et al.: Key Engineering Materials 329, **2007**

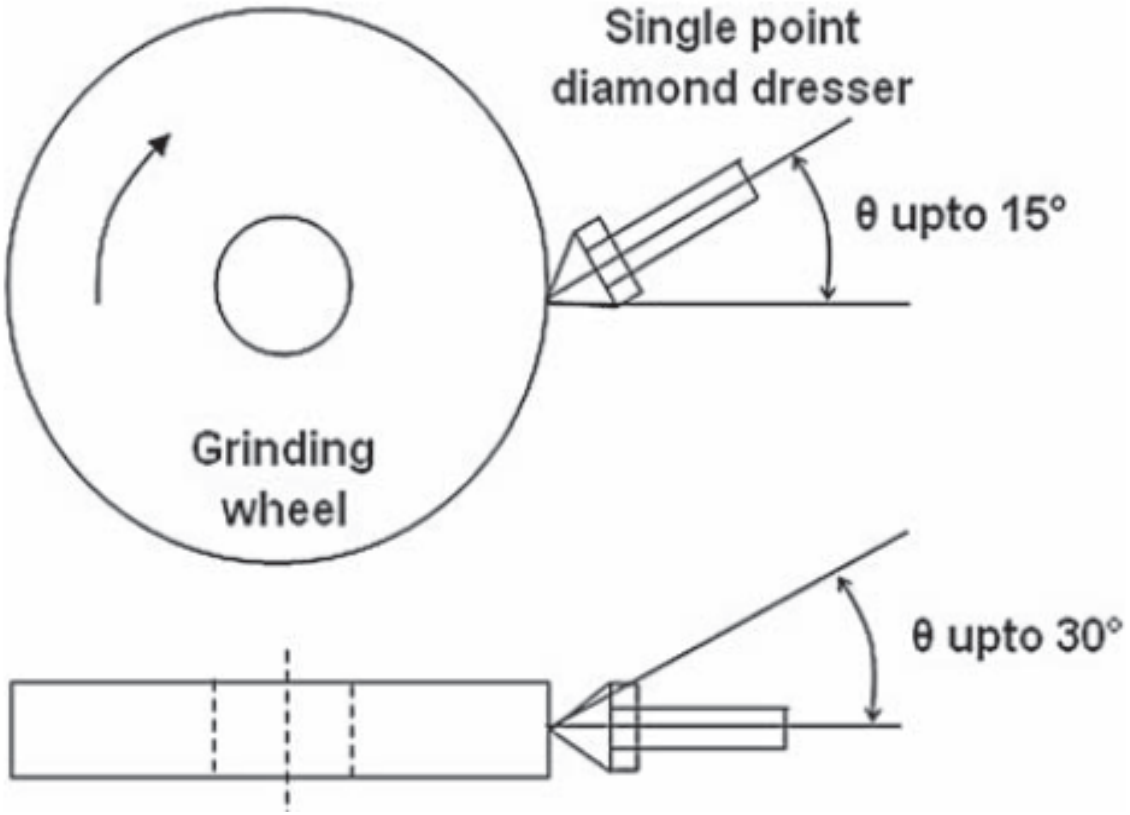


- blunting of cutting edges
- cracking of abrasive grains
- debonding of grains

decrease of material removal efficiency due to outwearing of the abrasive tool

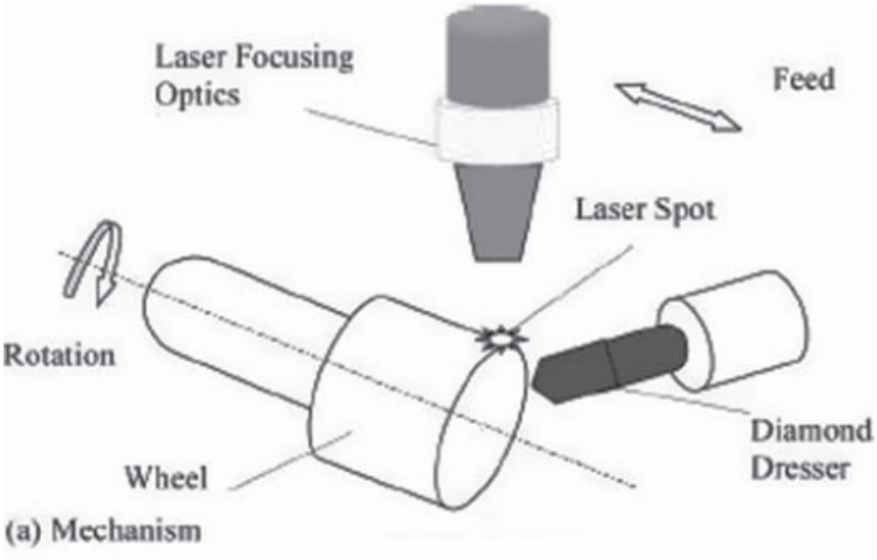
Conventional dressing

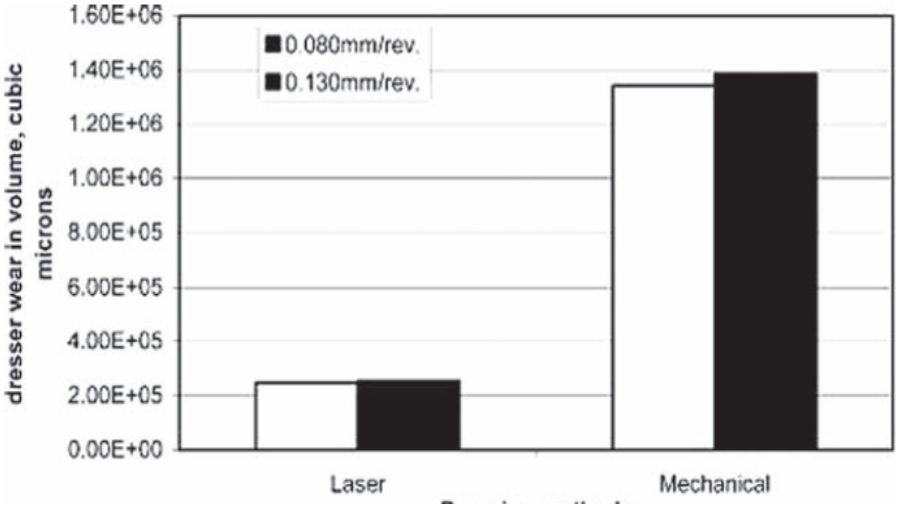
- mechanical dressing
- dressing tool (diamond)
- surface of dressing tool
- time consuming (hard materials)
- inefficient: 10% material removal with grinding, 90% with dressing



Laser Fabrication and Machining of Materials, *Springer US*, **2008**

Laser assisted dressing



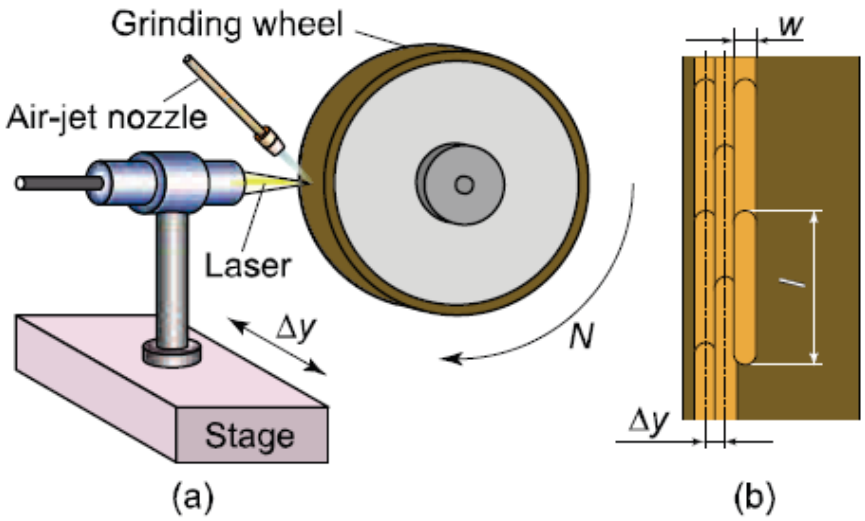


Zhang, Shin: *Int. Journal of Machine Tools and Manufacture*, 42, **2002**

- pre-heating of work piece
- softening of material
- easier removal with dressing tool
- weaker forces on dressing tool, increasing life time
- improvement of surface quality

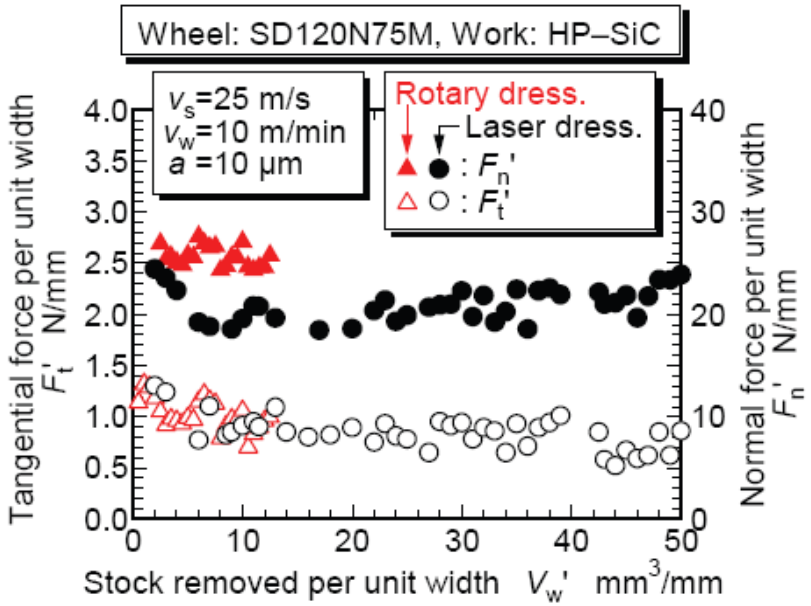
Laser dressing of SiC or diamond grinding wheels

Ablation of the grinding wheel by melting and blow out with ms pulses
(Nd:YAG laser, up to 1 kW)



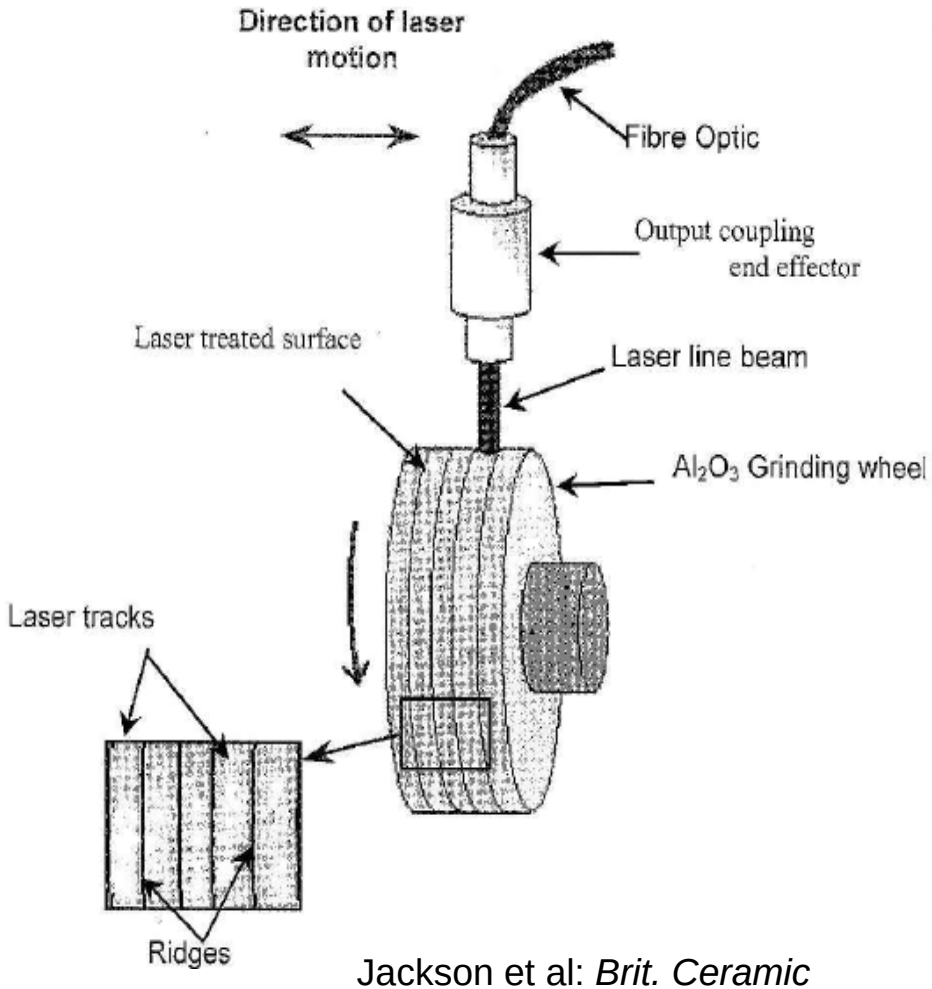
a) exp. setup, b) overlapping of thermal traces on grinding wheel surface

Hosokawa et al: *Annals of the CIRP* 55, ***2006***



forces during grinding process

Dressing of Al_2O_3 grinding wheels



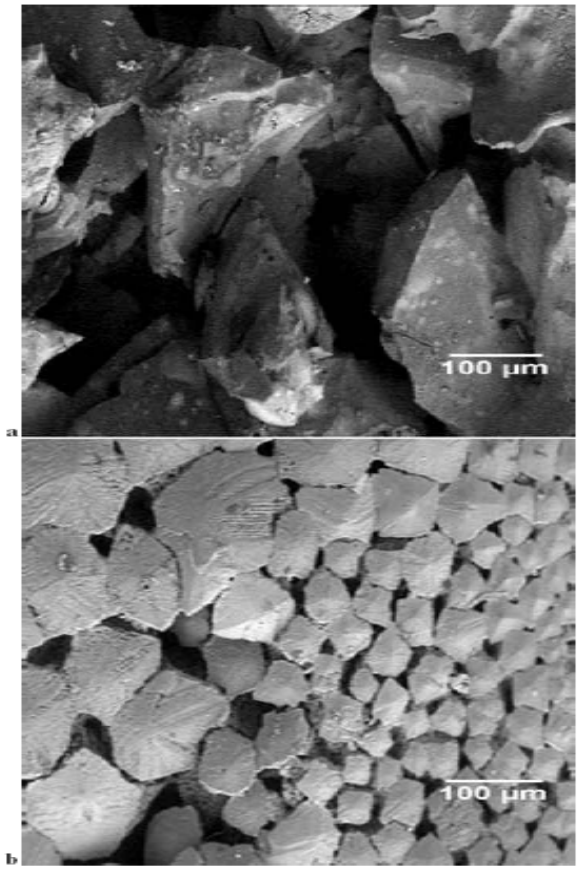
Jackson et al: *Brit. Ceramic Trans*. 102, **2003**

laser	
type:	Nd:YAG
op. mode:	cw
power:	2.5 kW
speed:	50 cm/s

- no air nozzle
- cw for high heat influence
- little material removal
- goal: restructure the wheel surface

Rapid solidification

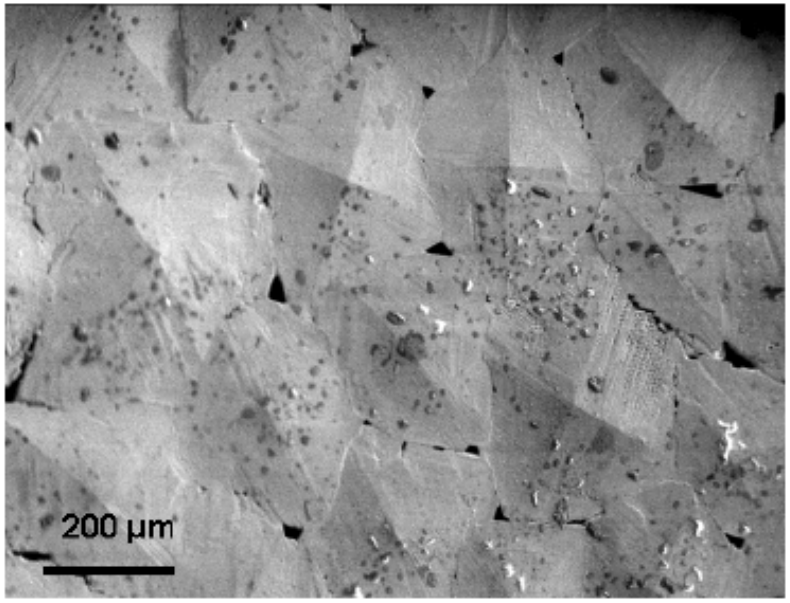
- cracking and melting of grains
- fast re-crystallization of the surface
- smoother surface
- bonding between grinding grains
- change of grain shapes



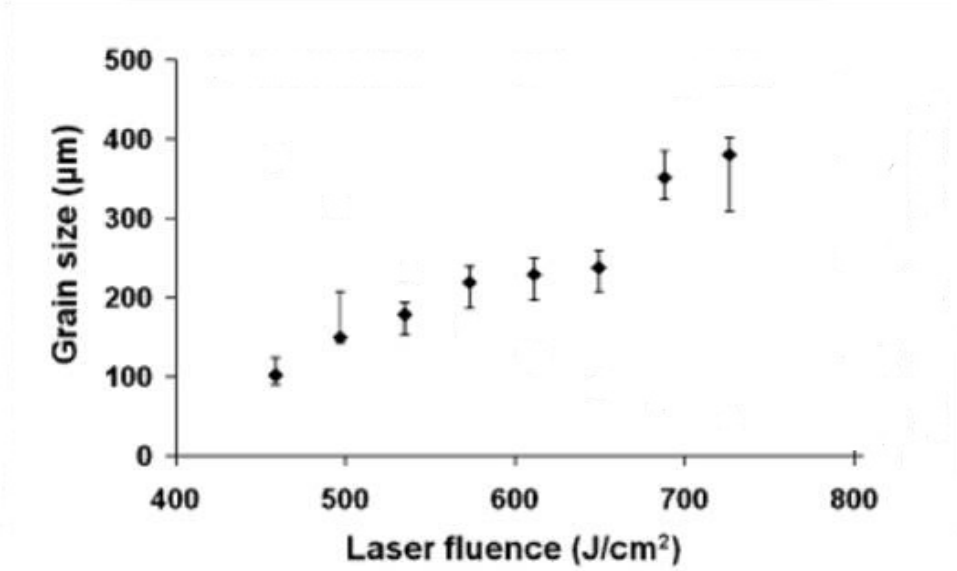
Al_2O_3 Grinding wheel: top before laser dressing, buttom: after laser dressing

Jackson et al: *Brit. Ceramic Trans*. 102, **2003**

Reforming of cutting edges and microstructures



Harimkar, et al. :*J. Phys. D: Appl. Phys.*39, **2006**

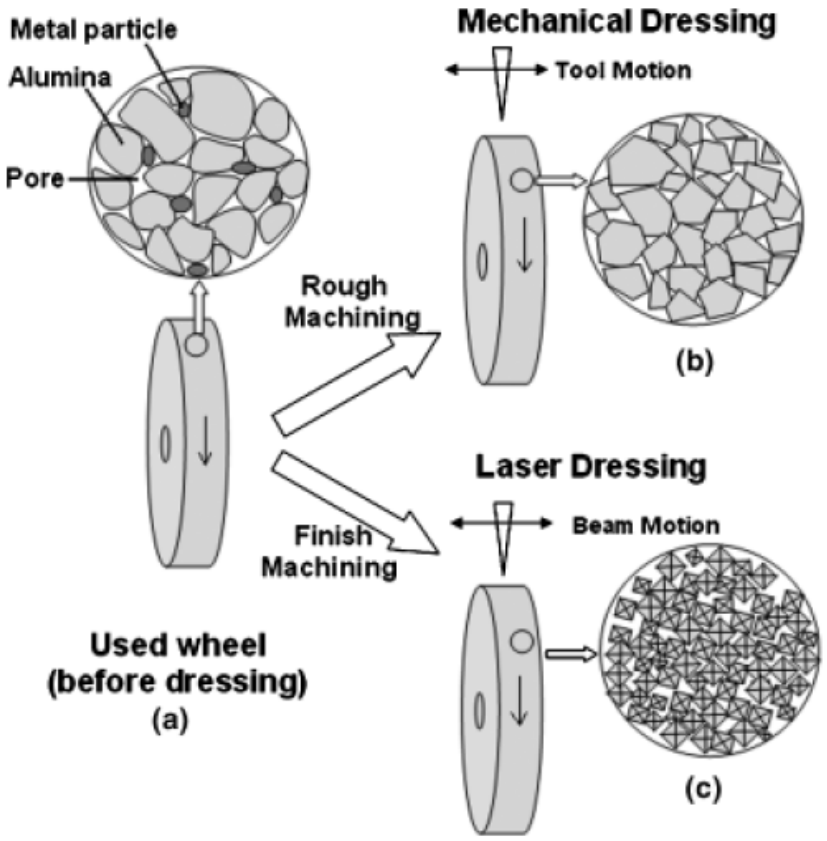


resulting grain size after laser dressing

Harimkar, *Dahotre:Int. J. Appl. Ceram. Technol*., 3, **2006**

- new regular build vertices and edge
- production of micro cutting edges
- grain size is well controllable

Conclusion



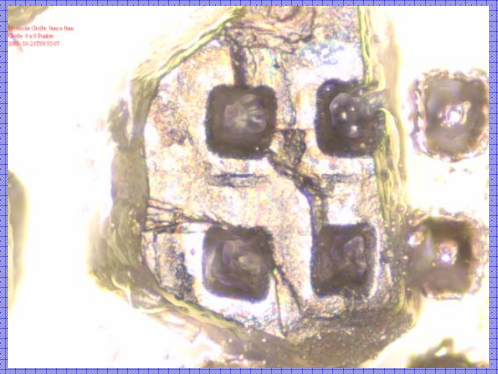
- dressing improves surface of tools
- mechanical dressing
  - rough surface
- laser-assisted dressing
  - weakening of surface
  - smaller forces during processing
- laser dressing
  - cracking and melting of grains
  - re-solidification of grains
  - improvement of surface quality

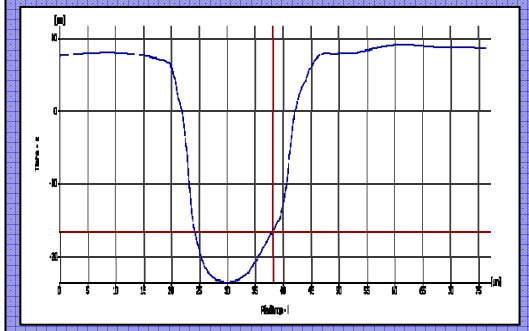
Our approach

- laser dressing of diamond tools
  - diamond is the hardest material
- diamond – diamond machining is time consuming
- short pulsed laser ns, ps
  - well controlled ablation, small HAZ
- processing tools with complex geometries
  - beam delivery

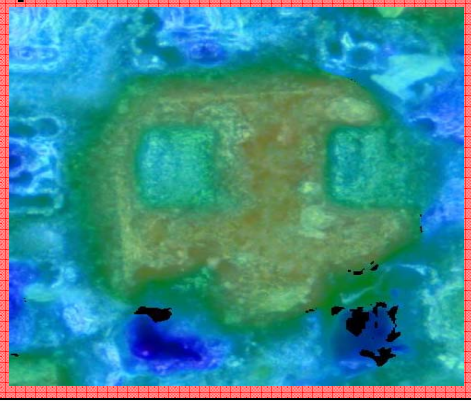
Laser ablation on single diamond grain

nano - seconds

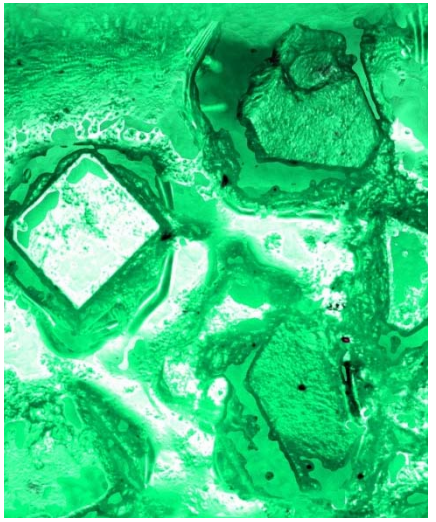




pico - seconds



replica technique



- structuring is possible with nano- and picosecond pulses
- height profiles
- replica technique, pre – post processing comparison

Outlook

- detailed analysis from nano- and picosecond ablation experiments
- determination of ablation rate
- microstructure analysis
  - SEM, Raman
- grinding experiments with processed grains, tools
- integration in process, machine design
- CTI - project