ETCHING EQUIPMENT @ GEORGIA TECH

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Process Support Manger

CREATING THE NEXT

Georgia Tech Institute for Electronics and Nanotechnology

ETCHING EQUIPMENT OVERVIEW

Georgia Tech Institute for Electronics and Nanotechnology

DRIE-ICP		RIE		Cleaner
Bosch Process	Non-Bosch Process	F-Chemistry	Cl-Chemistry	O_2-Chemistry
STS ICP	STS AOE	Plasma-Therm RIE	Plasma-Therm SLR RIE	Y.E.S. plasma cleaner
STS HRM ICP	STS SOE	Vision RIE		Gasonics Asher
STS Pegasus	Plasma-Therm ICP left chamber	Oxford End-Point RIE		Technics Micro RIE
Plasma-Therm ICP right chamber	Plasma-Therm ICP single chamber	Unaxis RIE		LFE Barrel Etcher

Chemical Vapor Etch	ION Beam Etch	Laser Machining
Xactix XeF2 Etcher	FEI Nova FIB/SEM	Hermes LS 500XL CO2
AMMT Hydrofluoric (HF) Vapor Etcher		Resonetics IR

STS MULTIPLEX ASE DRIE

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Applications

- Deep Silicon Trench Etch
- Through Silicon Via Etch
- SOI Wafer Etching

Substrates material and acceptable Masks

- Substrates: Si, poly-Si, a-Si, SOI
- Mask: Resist, SiO_2

Specifications

- Coil: 1000W 13.56 MHz ENI ACG-10B
- Platen HF: 500W 13.56 MHz ENI
- Platen LF: 300W 380 kHz AEI
- 8-pin ceramic clamp for 100mm w/ HBC Lip Seal

Gases: C_4F_8, SF_6, O_2, Ar

Process Pressure: 2 – 80 mTorr

Substrate Size: small piece – 4” wafers (6” wafer capability)

Temperature: 5-40 ℃ (platen), 40 ℃ (walls), 45 ℃ (lid)

Recent Service/Modification:

- RF bias – Power supply fix

STS HRM ICP

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Applications:

- General MEMS processes
- Narrow high aspect-ratio trench etching

Substrate materials and acceptable masks:

- Substrate: Si, poly-Si, α-Si
- Masks: SiO_2, Photoresist

Component specifications:

- Coil: 3000W 13.56MHz AEI
- Platen HF: 500W 13.56MHz ENI
- Platen LF: 500W 380KHz AEI LF5
- Backside helium cooling with electrostatic chuck

Gases: SF_6, C_4F_8, Ar, O_2, CO_2

Process Pressure: 5-80 mTorr

Substrate Size: small pieces - 4" wafers (6"wafer capability)

Temperatures: -20˚C-100˚C

Recent Service/Modification:

- RTD Failure, RF PS Service

STS DRIE ASE PEGASUS

Application:

- Silicon Trench Etching (Bosch process)

Materials material and acceptable masks:

- Substrate: Si, poly-Si, α-Si
- Masks: Photoresist, Si_3N_4, SiO_2

Component Specifications:

- Coil: 5000W 13.56MHz MKS
- Platen HF:500W 13.56MHz ENI
- Platen LF: 300W 380kHz AE LF5
- Backside helium cooling with electrostatic chuck

Gases: C_4F_8, SF_6, O_2, Ar

Process Pressure: 2-80 mTorr

Substrate size: small pieces – one 4" wafer or 6"

Temperatures:

- Platen -20°C to 40°C, Walls 120°C, Lid 120°C

Processing issues

- No general recipe
- Selectivity for PR is too low

STS MULTIPLEX DRIE AOE

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Applications:

- SiC high aspect ratio trench etch

Materials material and acceptable masks:

- Substrate: SiO_2, quartz, Pyrex, fused silica, Si_3N_4, Diamond
- Masks: Si, PR & Metals (Cr, Ti, Ni, Al)

Component specifications:

- Coil: 3000W 13.56MHz AE
- Platen: 1000W 13.56MHz ENI
- Backside Helium Cooling with Standard 8-pin clamp & lip seal

Gases: C_4F_8, SF_6, O_2, H_2, CF_4, two open gas slots

Process Pressure: 2-80 mT

Substrate size: small pieces – single 4" (6") wafer

Temperatures: Platen -20 to 120 C, Walls 100 C, Lid 120 C

Recent Service/Modifications

- Failed interlocks, repaired IO Boards, repaired computers

STS DRIE SOE

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Applications

- Shallow Silicon trench etching
- III-V etching

Materials material and acceptable masks:

- Substrates: SiO_2, Si, III-V
- Mask: Resist, SiO_2, Si_3N_4, III-V

Gases: CH_4, H_2, Cl_2 BCl_3, HBr, CHF_3, CF_4, Ar, O_2, N_2

Specifications

- Coil: 1000W 13.56 MHz ENI
- Platen: 300W 13.56 MHz ENI
- 8-pin ceramic clamp for 100mm w/ HBC Lip Seal

Process Pressure: 2 – 80 mTorr

Substrate size: small piece – 4" wafer

Temperature: -20 - 180 C (platen), 40 C (walls), 45 C (lid)

Recent Service/Modifications

Plasma-Therm DUAL SLR DRIE

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Dual Chamber Etching System Featuring:

- (Right) Si trench etch / poly-Si / through-wafer
- (Left) III-V etching; SiO_2 Si_3N_4 & Al / metal etching

Materials etched and acceptable masks:

- Etched/Left: SiO_2, Si_3N_4, Al, III-V → InP, InGaAs
- Mask/Left: Metal, Photoresist
- Etched/Right: Silicon, poly-Si
- Mask/Right: no metal masks (only PR, Si_3N_4, SiO_2)

Component specifications (both):

- Coil: 2000W 2.8MHz RFPP RF-20M
- Platen: 500W 13.56MHz RFPP RF-5S
- HBC: Both chambers
- Left: Ceramic Clamp; Right: ESC

Gases:

- Left: Cl_2, BCl_3, C_4F_8, CF_4, H_2, Ar, O_2
- Right: SF_6, O_2, C_4F_8, Ar

Process Pressure: (5-80mTorr both chambers)

Substrate: small pieces – 4” wafer, up to 6” in right chamber

Temperatures:

- Platen: Left 20°C; Right 20°C
- Chamber: 40°C

Recent Service/Modification:

- Right chamber HBC leak repaired
- Full platen PM for both chambers (seals, lift, cleaning)

PLASMA THERM ICP (SINGLE CHAMBER)

Georgia Tech Institute for Electronics and Nanotechnology

Single Chamber Etching System Featuring:

- III-V etching; SiO_2, Si_3N_4 & metal etching

Materials etched and acceptable masks:

- Etched: SiO_2, Si_3N_4, Al, III-V □ InP, InGaAs
- Mask: Metal, Photoresist

Component specifications (both):

- Coil: 2000W 2.8MHz RFPP RF-20M
- Platen: 500W 13.56MHz RFPP RF-5S
- HBC
- Left: Ceramic Clamp; Right: ESC

Gases:

- Cl_2, BCl_3, C_4F_8, CF_4, H_2, Ar, O_2

Process Pressure: 5-80mTorr

Substrate Size: small pieces – single 4” wafer,

Temperatures:

- Platen: 20°C
- Chamber: 40°C

Recent Service/Modification:

- Chamber HBC leak repaired

Plasma-Therm SLR RIE

RIE System Featuring:

- Loadlock and load arm

Materials etched and acceptable masks:

- Etched: Al, Cr, Ti, Si; III-V
- Masks: Photoresist; No SU8, BCB

Component specifications (both):

- 500W 13.56MHz RFPP RF-5S power supply

Gases:

- BCl_3, Cl_2, O_2, Ar, H_2

Process Pressure: 5-80mTorr

Substrate: small pieces – one 8” wafer

Temperatures:

- Platen 5-40°C

Plasma-Therm RIE

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Dual Chamber Etching System Featuring:

- Si, SiO_2, Si_3N_4 & Al / metal etching
- III-V etching
- Polymer etching

Materials etched and acceptable masks:

- Left: Al, Cr, Ti, Si, poly-Si, metals, III-V
- Right: Si, SiO_2, Si_xN_y polyimide, SU8. BCB
- Masks: Metal and PR

Component specifications (both):

- 500W 13.56MHz RFPP RF-5S Power supply

Gases:

- Left: O_2, BCl_3, Cl_2, Ar
- Right: Ar, CHF_3, O_2, CF_4/SF_6

Process pressure: 10-800mTorr both chambers

Substrate:

- Left: small pieces – one 8” wafer
- Right: small pieces - four 4” wafers

Temperatures:

- Left Platen 40°C; Right 40°C

ADVANCED VACUUM VISION RIE 1 &2

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Materials etched and acceptable masks:

- Etched: SiO_2, Si_3N_4, Si
- Masks: oxide and photoresist

Component specifications:

- 600W 13.56MHz Seren power supply

Gases:

- Ar, N_2, O_2, CF_4, SF_6, H_2

Process Pressure: 10-800mTorr

Substrate: Small pieces – one 8” wafer

Temperature: 5-40°C

Recent Service/Modification:

- Throttle valve failure. Will require retrofit by Plasma-therm or custom control system in-house

OXFORD END-POINT RIE

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Applications:

- General plasma etching

Materials etched and acceptable masks:

- Etched: SiO_2, Si_yN_x
- Masks: photoresist, metal

Component specifications:

- 500W 13.56MHz AE – Platen
- Power: 300W

Gases: Ar, O_2, CHF_3, CF_4

Process Pressure: 5-500 mTorr

Substrate: small pieces – one 6” wafer

Temperatures: 5-45˚C

Recent Service/Modification:

- Intermittent I/O failures. Possible candidate for PLC/CtrLayer Upgrade

UNAXIS RIE

Functions:

- Shallow silicon etching

Materials Etched and acceptable masks:

- Si
- Masks: Si_3N_4, SiO_2, photoresist

Component specifications:

- 500W 13.56MHz AE RF5S– Platen

Gases: CHF_3, O_2, Ar

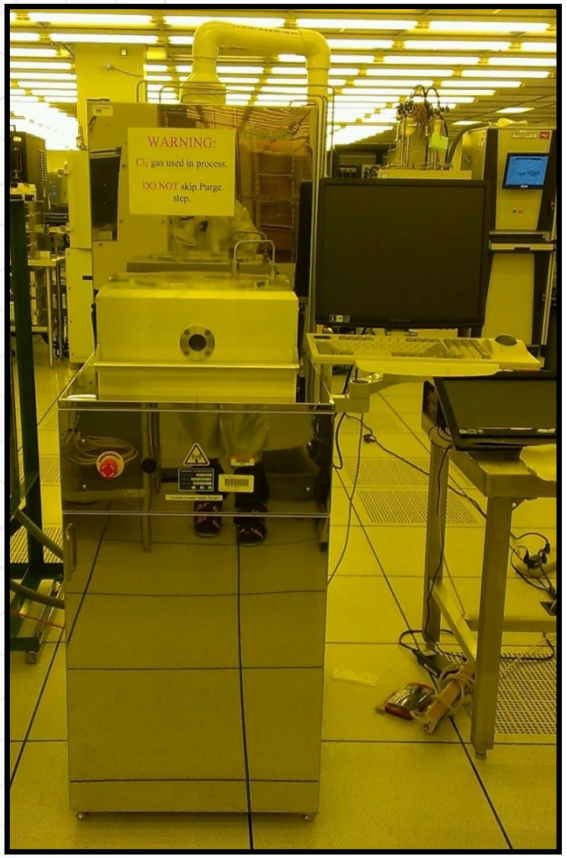
Process Pressure: 10-800mTorr

Substrate: small pieces-4” wafer (up to 3)

Temperatures: 5-40°C

Recent Service/Modification

- HDD Failure, computer IO damaged



Y.E.S.-R1 PLASMA CLEANER

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Functions:

- Descum and remove residual organics and thin oxides
- Controlled through MicroLogix PLC upgrade

Component specifications:

Gases: O_2 , Ar, N_2

Process Pressure: 1500mTorr

Substrate: size varies upon user request

Temperatures: 25-80˚C

GASONICS ASHER

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Applications:

- Photoresist stripper for front and backsides of wafers
- Descum (200-500 Angstroms of photoresist)

Component specifications:

- Load arm

Gases: O_2 and N_2

Process Pressure:

Substrate: 4” wafers, 1-10 wafers per run

Temperatures: 25-200°C

TECHNICS MICRO-RIE 1&2

Georgia Tech Institute for Electronics and Nanotechnology

Applications:

- Simple descum and surface activation

Materials etched:

- Etched: Si, polymer

Gases: O_2, N_2

Substrate: small pieces – 4” wafer

XACTIX XEF2 E1 SERIES XETCH

Vendor-specified system features:

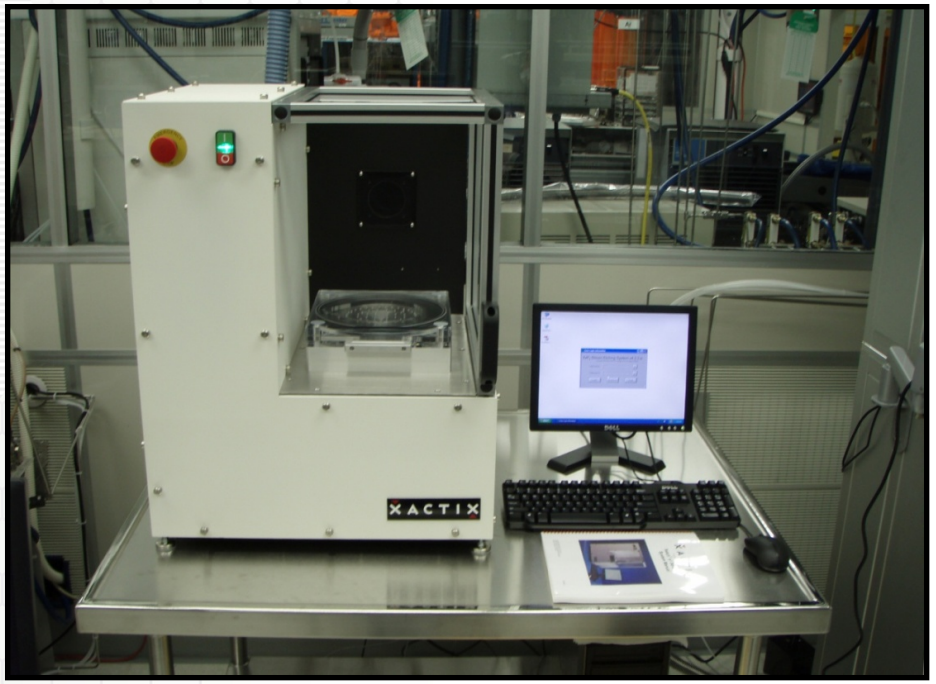
- Excellent selectivity SiO_2:Si (1000:1), good selectivity to PR
- Potential to etch very small devices (30nm)
- Etch does not attack Bosch passivation layer – can switch between tools and still protect trench walls

Materials etched and acceptable masks:

- Etched: Si, poly-Si
- Masks: PR, SiO_2, Si_3N_4

Gases: XeF_2

Substrate: 1 die – 6” wafer (specialized chuck)



AMMT HYDROFLUORIC (HF) VAPOR ETCHER

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Applications:

- SiO_2 thin film release

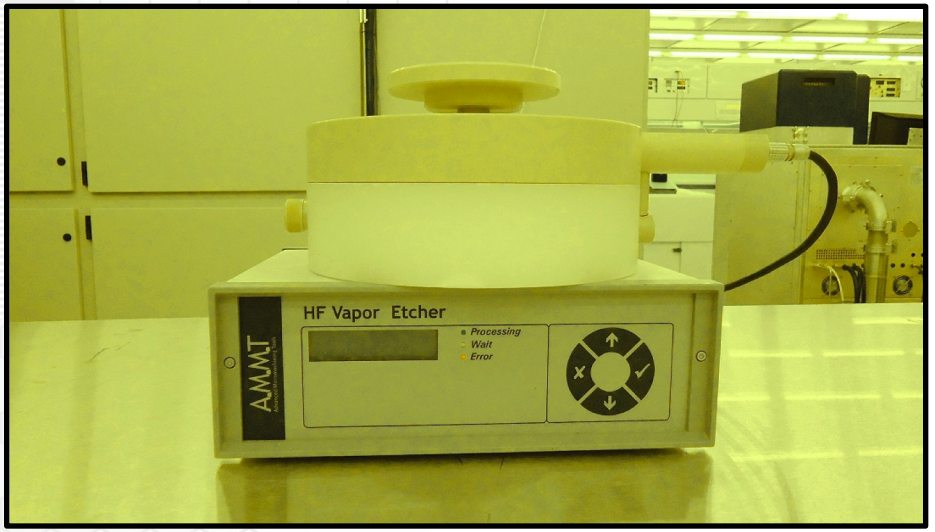
Materials etched and mask:

- substrate: SiO_2,
- Mask: polymer

Etchant: 49% HF solution

Substrate: small pieces – 4” wafer

Temperature: room temperature to 60 C



FEI NOVA NANOLAB 200 FIB/SEM

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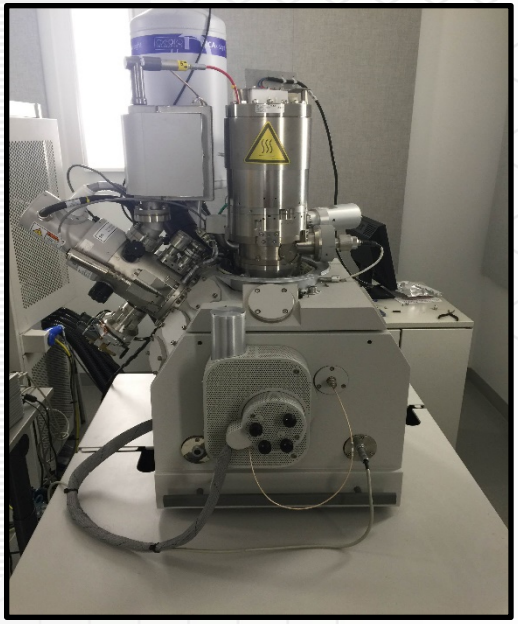
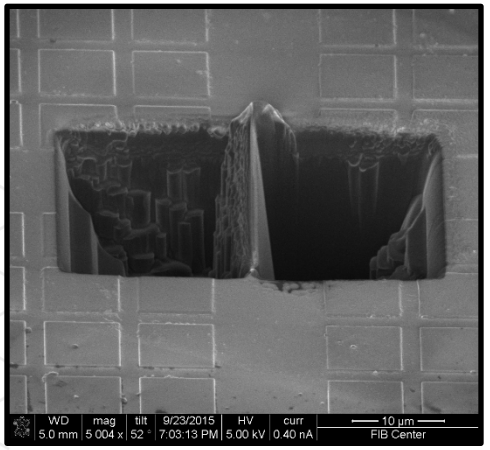
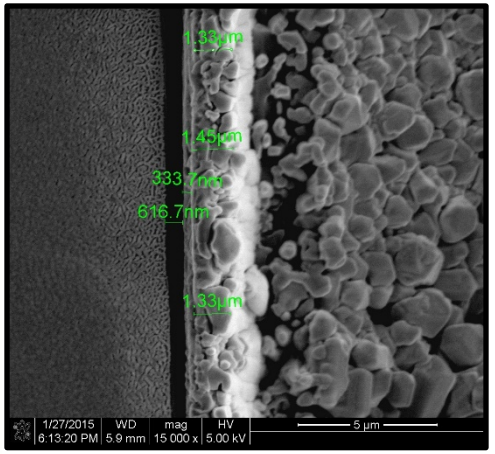
system features:

- Ga ion beam, 30KV max
- 30-50 nm min. line width etched
- 40nm Pt line deposition
- TEM lamella preparation via micro-manipulator
- EDX of cross-sections
- Circuit editing via etching and deposition of Pt







LASER LAB

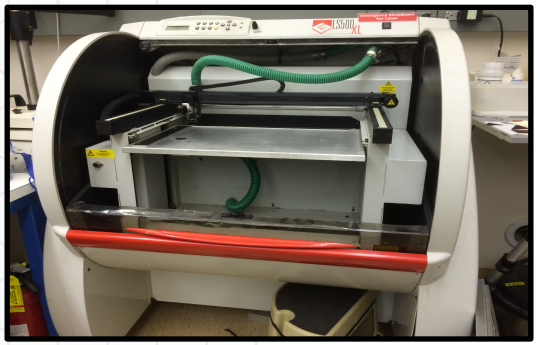
Hermes LS500XL CO2

Functions:

- CO_2 laser @60W, approx 1mm wavelength
- Resolutions of 200um spot and sub mm movement

Materials etched:

- Polymers, wood, papers, plastics



Resonetics IR

Functions:

- Nd-YLF laser @16W, 1047nm wavelength, 180us pulse/ms
- Resolutions of 50um spot and um movement

Materials etched:

- Any metal up to 200um thick

NEW TOOLS – OPTEC WS FLEX FEMTOSECOND LASER

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Wavelength (nm)	1028nm; 4W
Machining head	Galvo scanner, fixed lens, cutting head
Laser type (pulse duration)	Nanosecond, picosecond, femtosecond
Max. Scanner field (if applicable)	Up to 20x20 mm^2 scan area
Minimum Spot size	<5 µm
XY stages travel	300x300 mm
Outer dimensions in mm (HxWxD)	2250x890x1250
Common options	Rotary stages, Tube lathe, Fume extraction

EFFECT OF FEMTOSECOND LASER

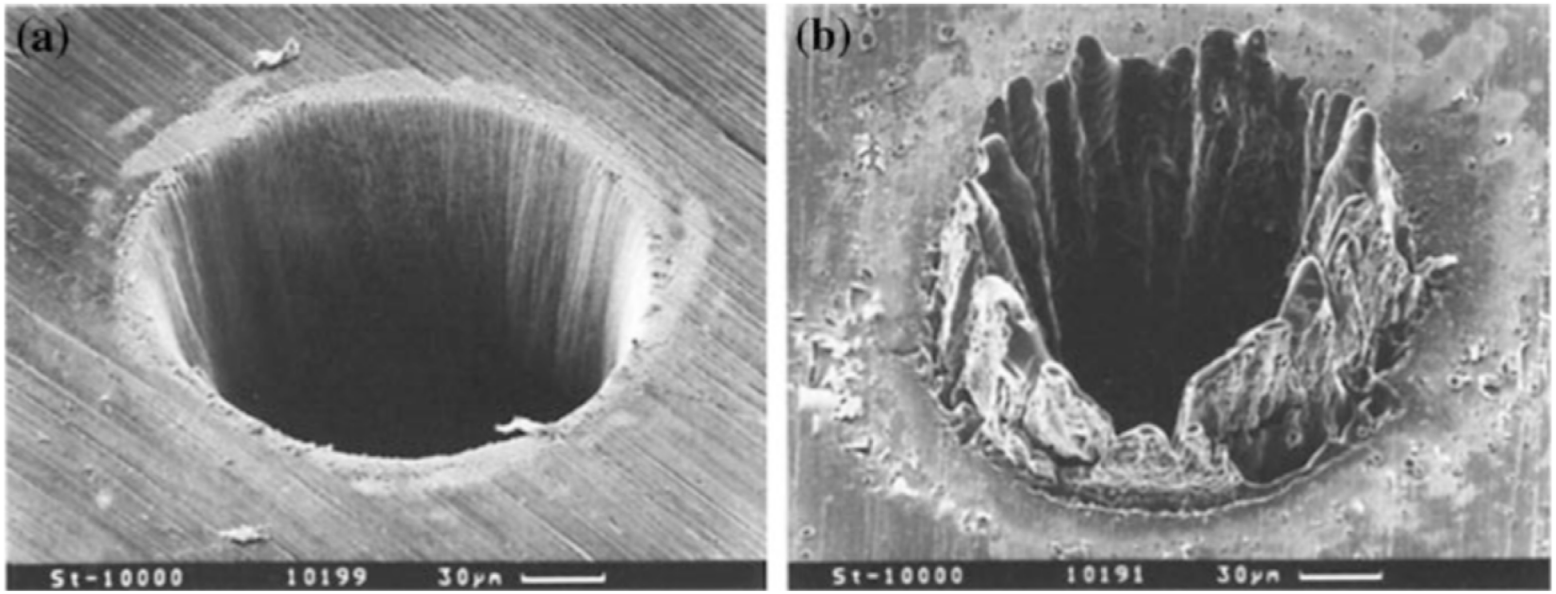

Fig. 6.6 Laser ablation craters in a 100 μm thick steel foil with (**a**) 200 fs, 780 nm and 120 μJ; and (**b**) 3.3 ns, 780 nm and 1 mJ laser pulses (After Chichkov et al. [37])

Femtosecond Laser Ablation: Fundamentals and Applications
Sivanandan S. Harilal, Justin R. Freeman, Prasoon K. Diwakar and Ahmed Hassanein

POSSIBLE NEW TOOL-OMEGA® SYNAPSE™ FOR DIELECTRIC ETCH

Georgia Tech Institute for Electronics and Nanotechnology

Advantages of Synapse™

- High MTBC - The process chamber can be heated to ~130ºC to reduce the amount of by-product deposition and improve MTBC. The chamber is also surrounded by permanent magnets which result in a higher plasma density than conventional ICPs (by a factor of ~10x).
- High Etch Rate – Higher plasma density means higher etch rate of strongly bonded materials and the capability of running at reduced pressure. The latter extends mean free paths and leads to better directionality and less by-product 'fencing'.
- Versalis-compatible – Can be fully integrated with different SPTS etch and deposition modules on a Versalis cluster platform

Materials including…

- SiO2 (including deep oxide etch >100 µm)
- Glass
- SiNx
- SiC
- GaN
- PZT and AlN
- Al2O3

IEN CLEANROOM WEBSITE

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http://SUMS.gatech.edu

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