Ultrafast DPSS laser interaction with thin-film barrier stacks

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Overview

Introduction

Facilities

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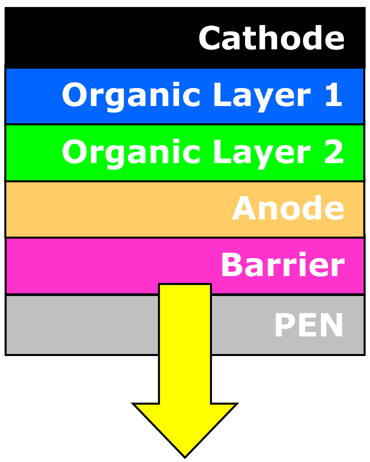
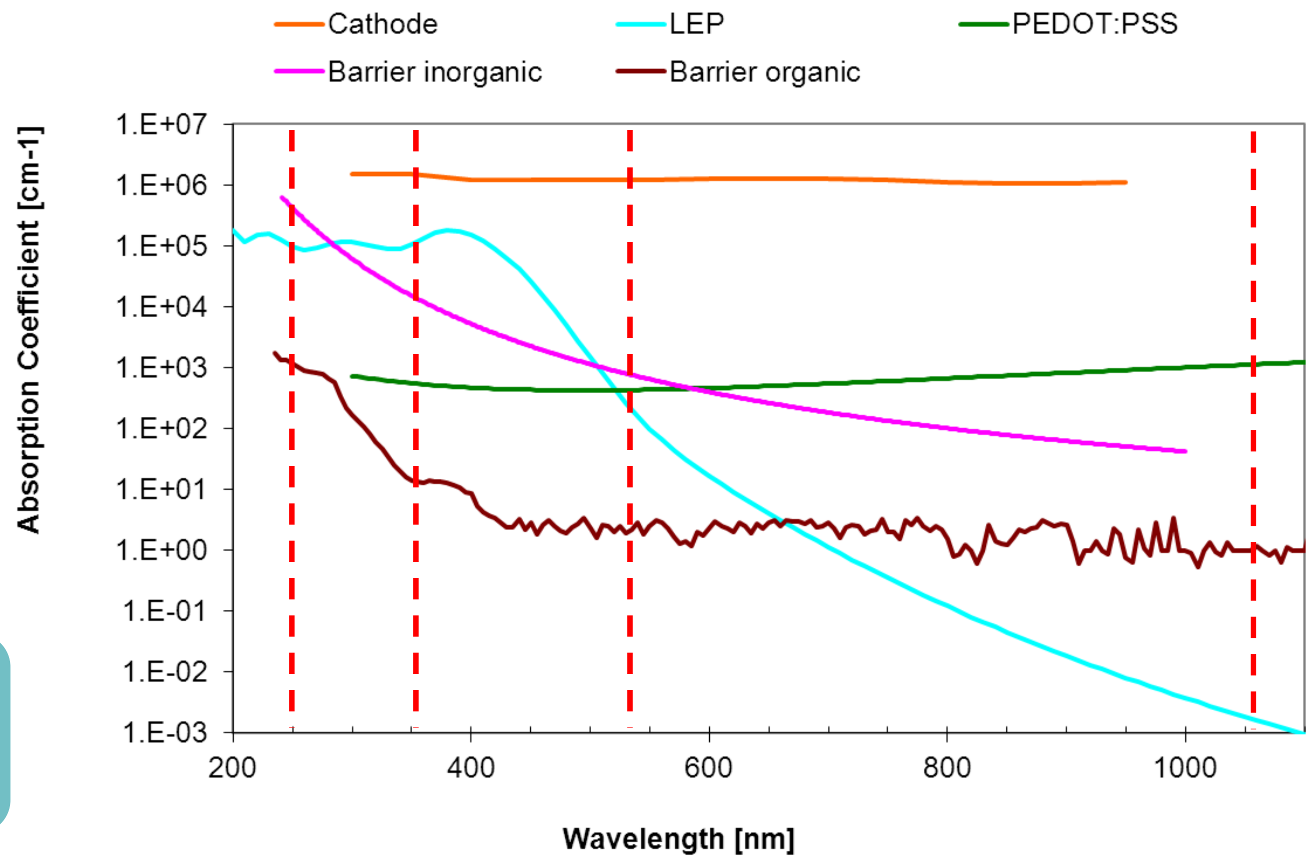
Introduction: thin-film laser patterning

- **Example: typical OLED layers optical properties**



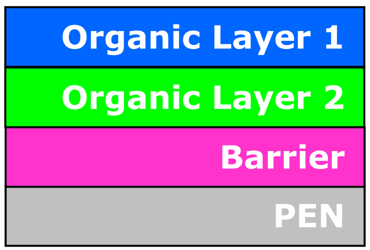
A single-laser wavelength will not be able to pattern all layers selectively

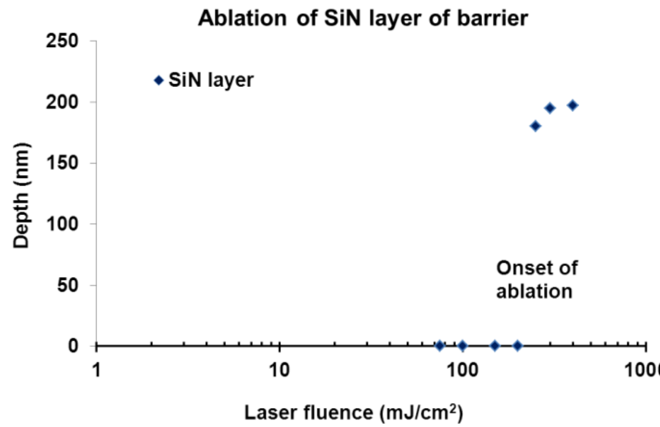


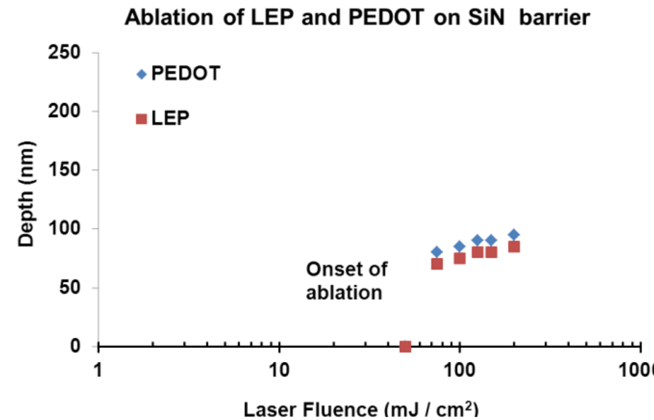
An absorption coefficient of 1.E+5 cm^{-1} corresponds to a beam penetration depth of 100 nm

Introduction: organics patterning using Excimer lasers

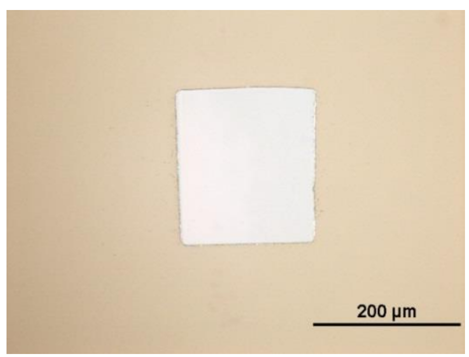
- **Example: PEDOT:PSS and LEP removal from barrier foils**
  - KrF Excimer laser (248 nm)

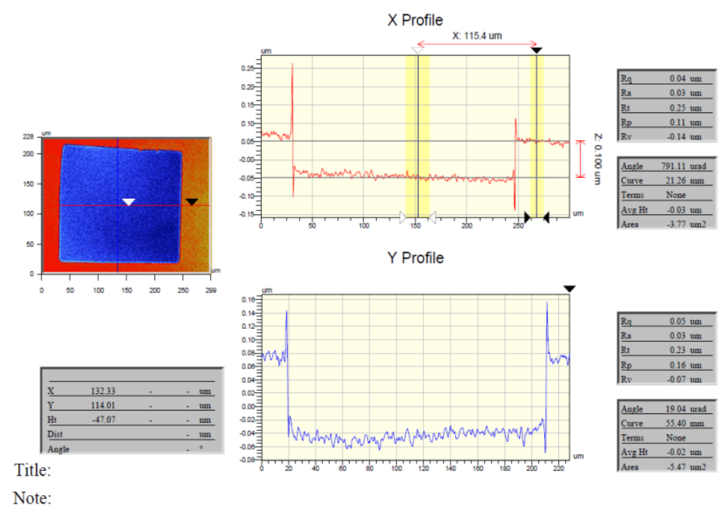






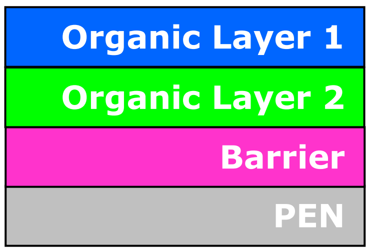
Single shot ablation of PEDOT and LEP on barrier is feasible

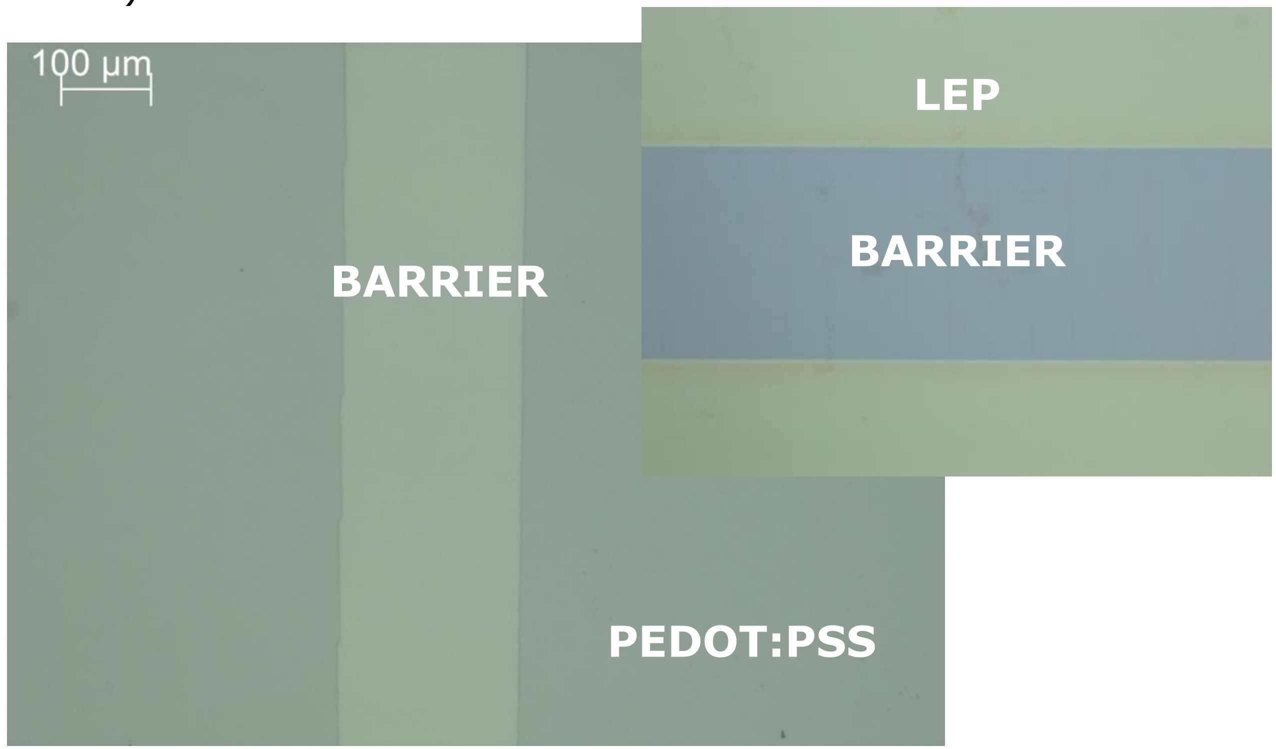




Introduction: organics patterning using Excimer lasers

- **Example: PEDOT:PSS and LEP removal from barrier foils**
  - KrF Excimer laser (248 nm)





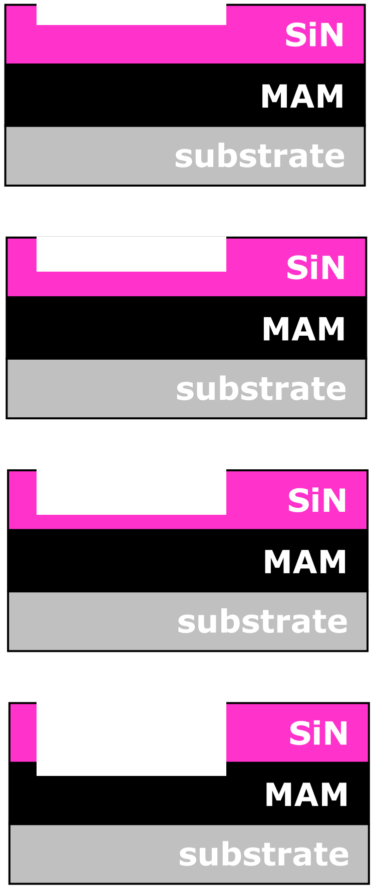
Convenient process window for organics patterning
Clean removal of PEDOT / LEP
No debris or flakes are observed

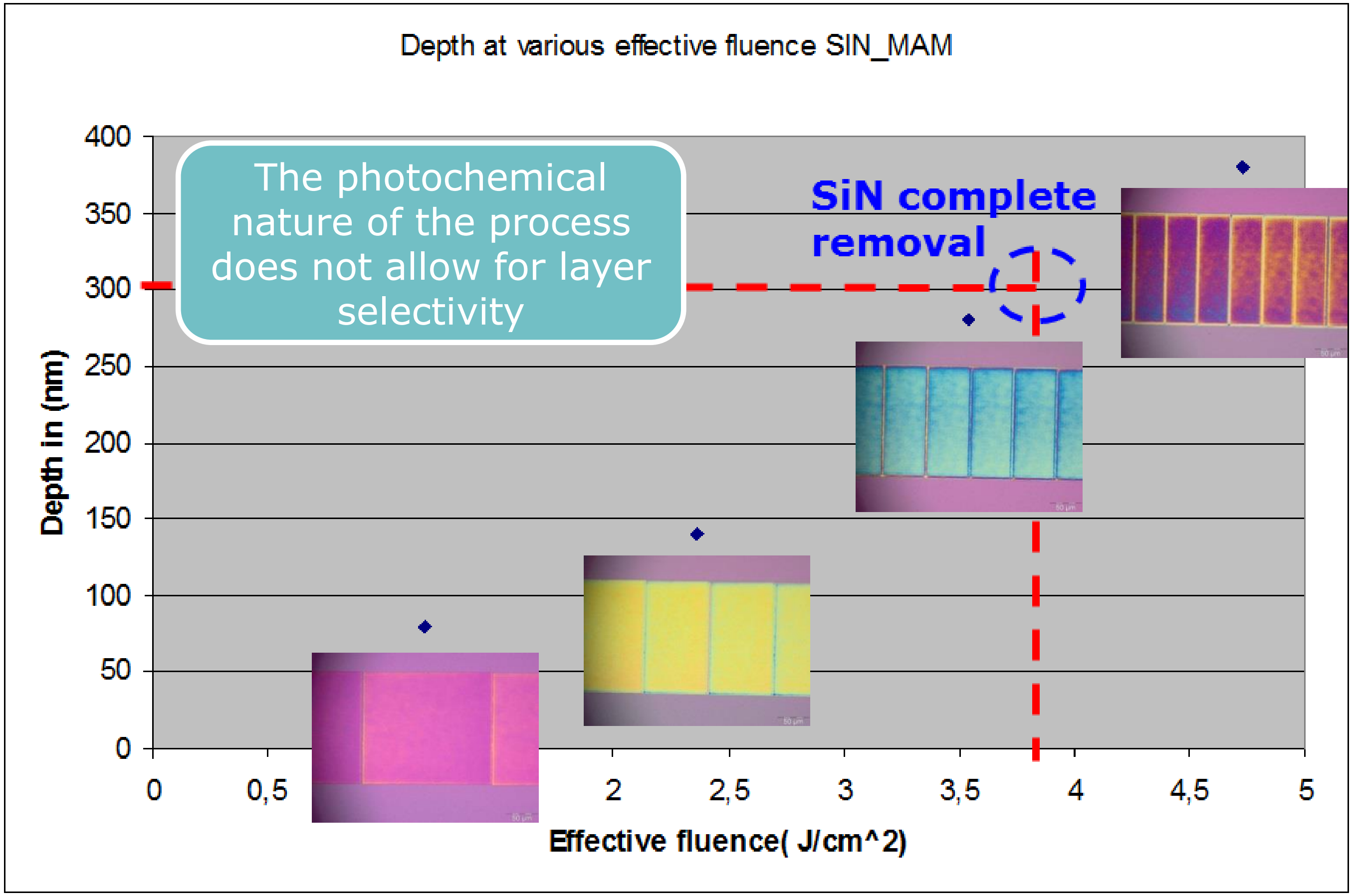
Detailed surface analysis after laser patterning.
Applied Surface Science 2013 (article in press)

Flexible OLED devices incorporating Excimer laser patterning have been demonstrated. *Applied Optics 2013 (under review)*

Introduction: inorganics patterning using Excimer lasers

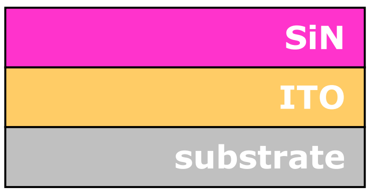
- **Example: (inorganic) barrier layer patterning on metal contacts**

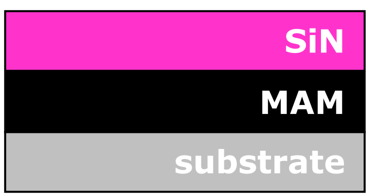


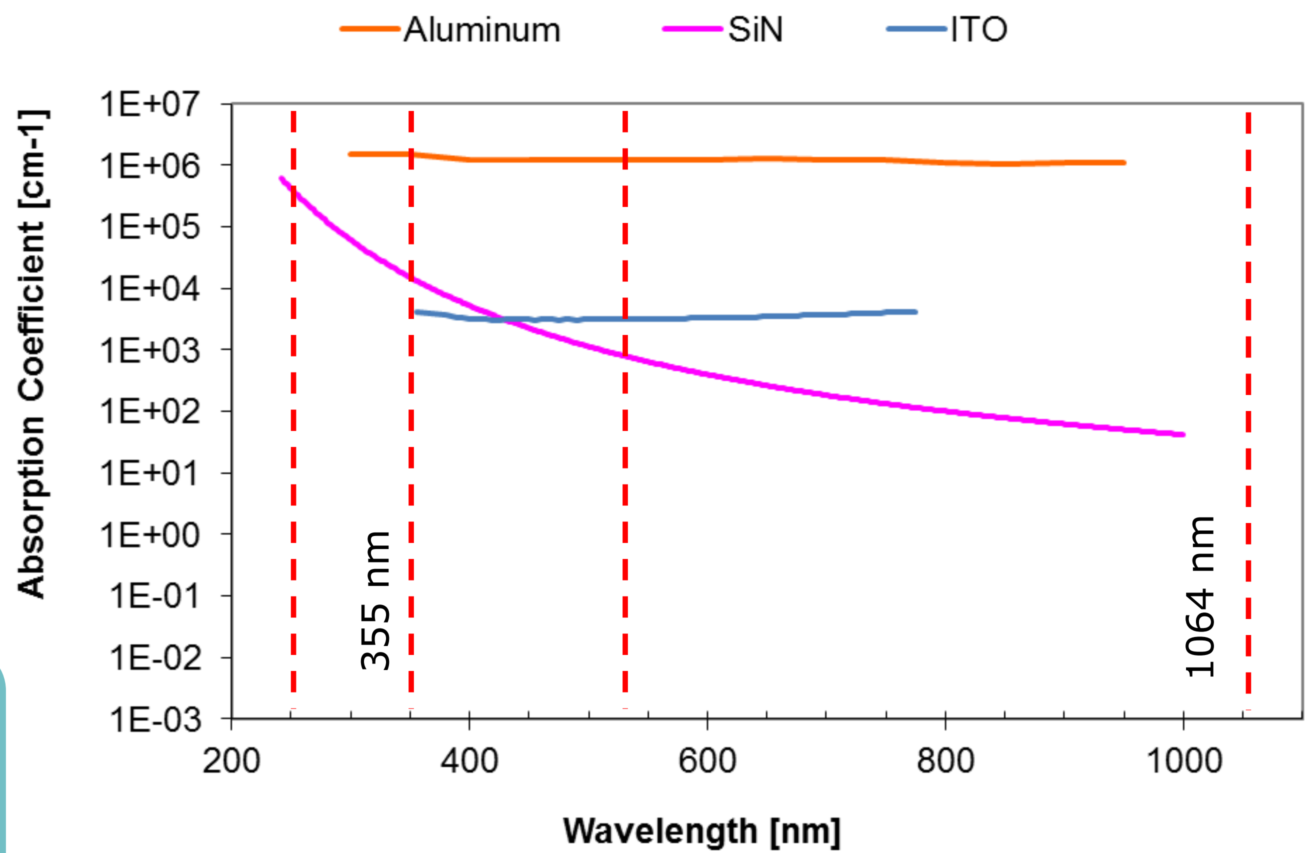


Introduction: inorganics patterning using DPSS lasers

- **Example: (inorganic) barrier layer patterning on metal contacts**







Goal is to study the influence of the wavelength and the pulse energy on the ablation mechanism

An absorption coefficient of 1.E+5 cm^{-1} corresponds to a beam penetration depth of 100 nm

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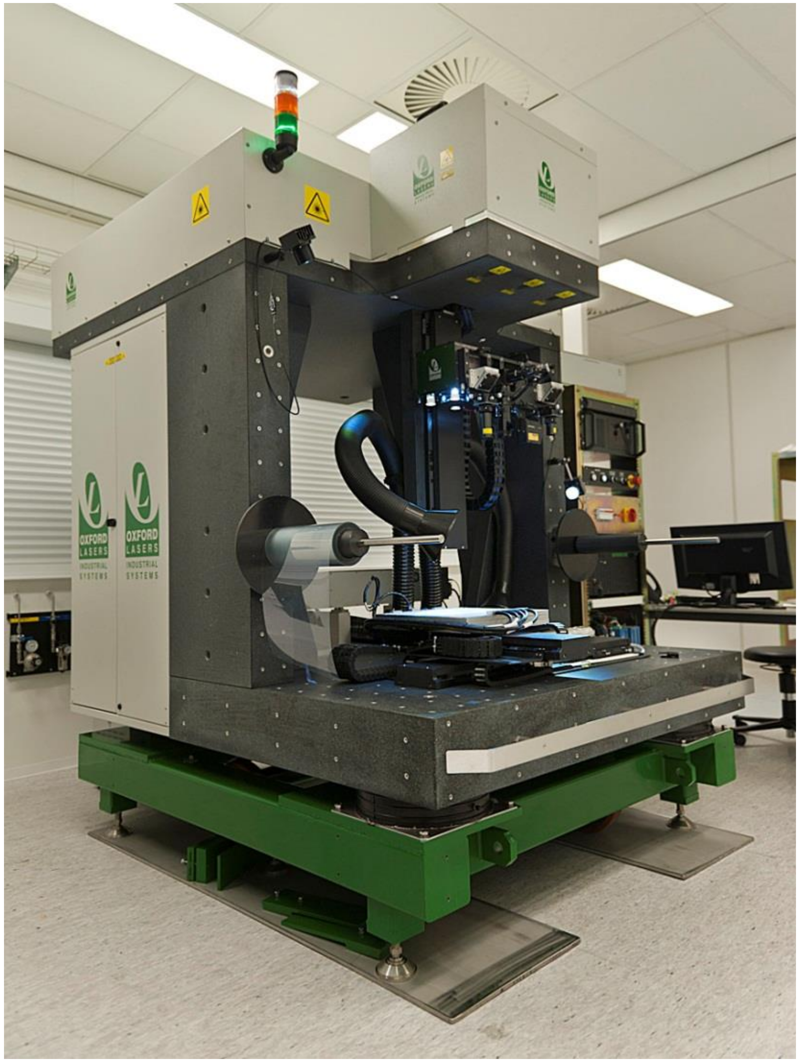
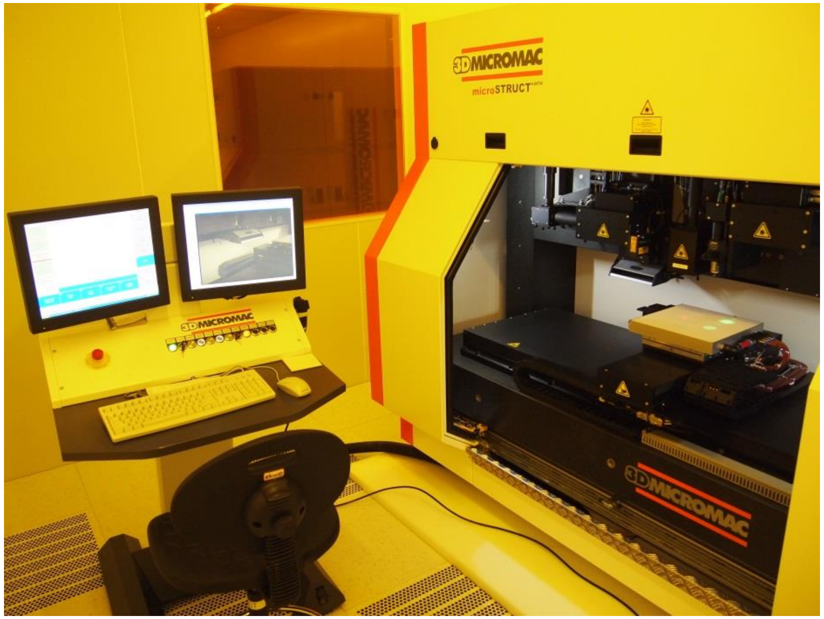
Ultrafast laser set-ups at TNO and imec





Coherent ps laser (Talisker)

TimeBandwidth ps laser (Duetto)

Amplitude Systems fs laser (Satsuma)

OVERVIEW

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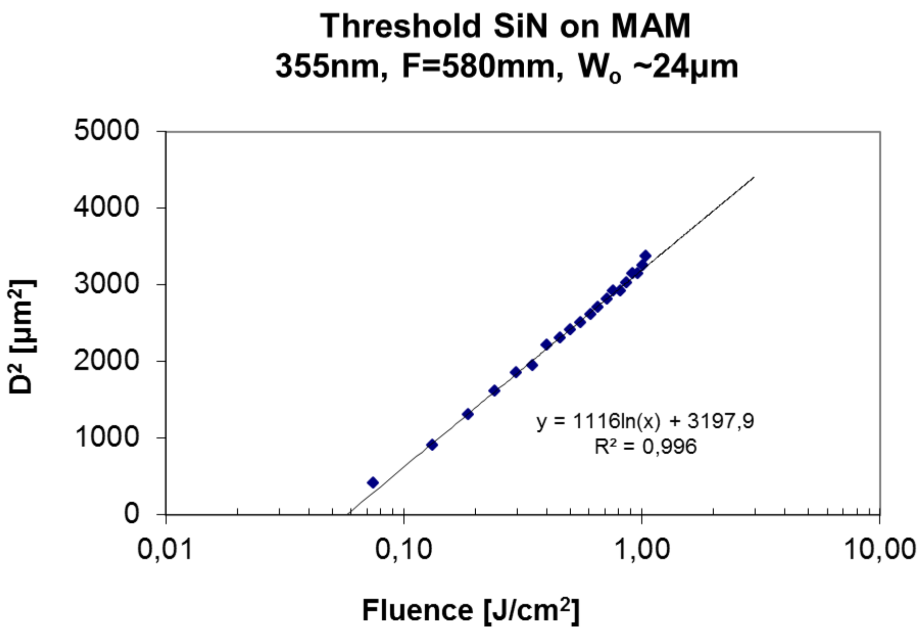
Results SiN on MAM / ps 355nm

SiN
MAM
substrate

- **Step 1: power scan / single pulse**
  - To determine the ablation threshold of the SiN on MAM
  - Find threshold for damage of the sub layers
  - To see the behavior of ablation mechanism(s) as function of laser pulse energy



Threshold SiN removal 60 mJ/cm^2

Photo-chemical assisted ablation
Laser fluence higher than 90 mJ/cm^2

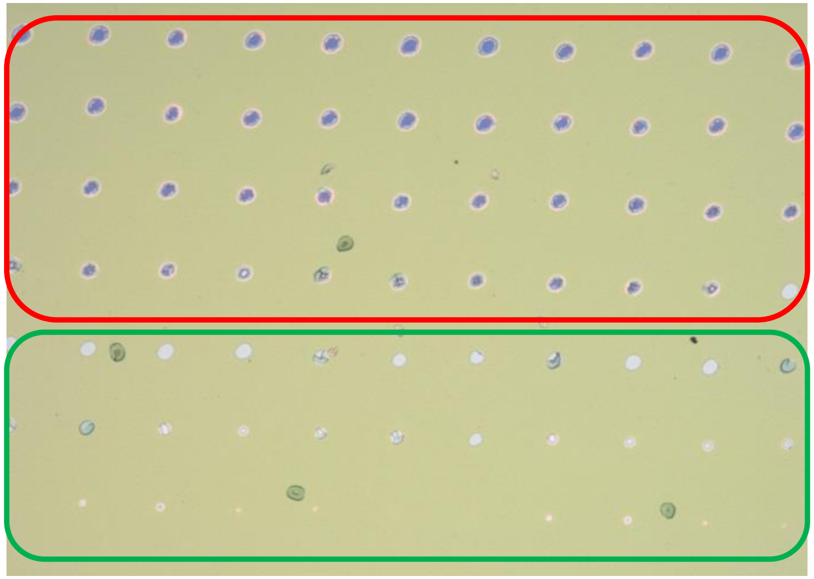
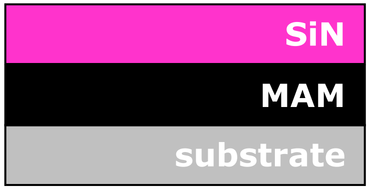
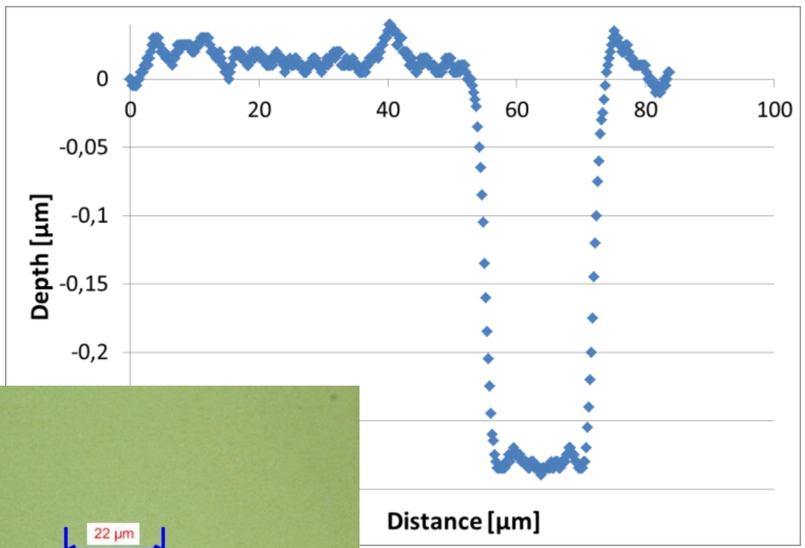


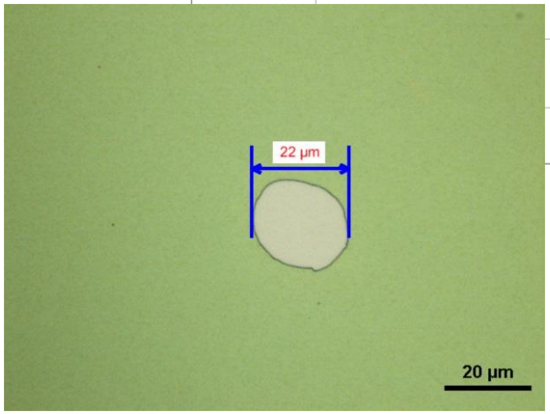
Photo-mechanical assisted ablation
Laser fluence < 90 mJ/cm^2

Results SiN on MAM / ps 355nm



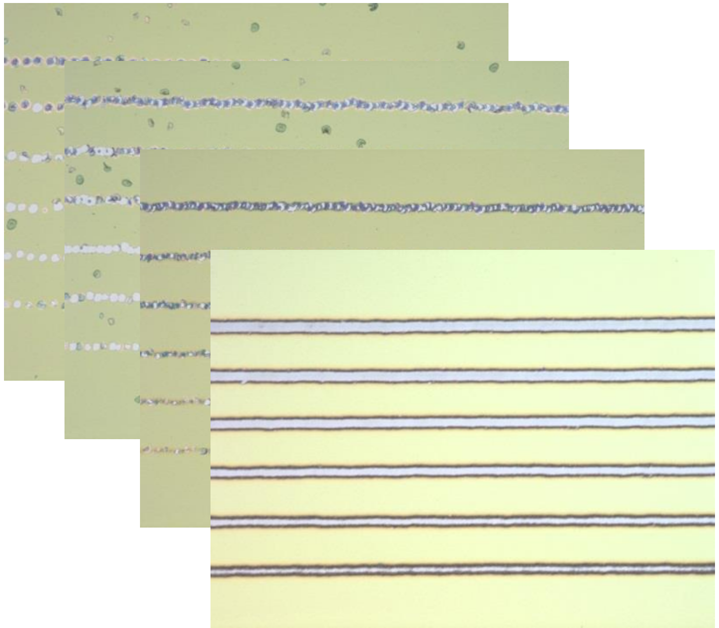
- **Step 2: photomechanical process optimization**
  - Complete SiN layer removal without introducing damage to the underlying layer
  - Single shot process seems to be instable
  - Improve laser patterning "process window" by tuning the pulse to pulse distance (P2P)





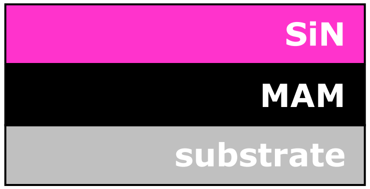
Selective removal of SiN on MAM

P2P distance: 24 → 16 → 8 → 1um

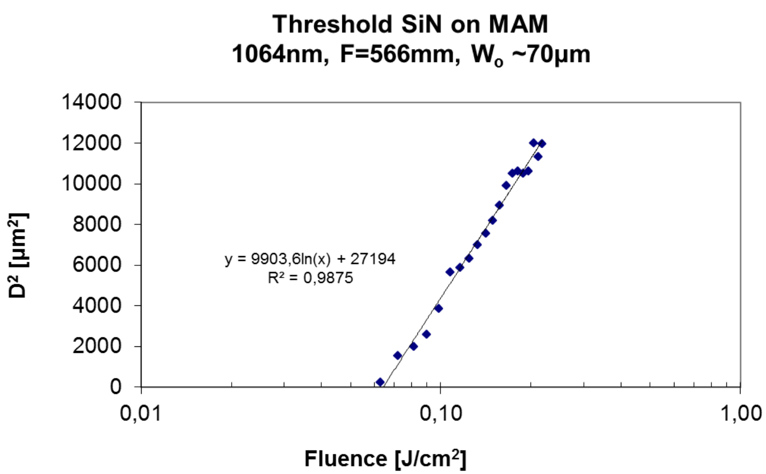


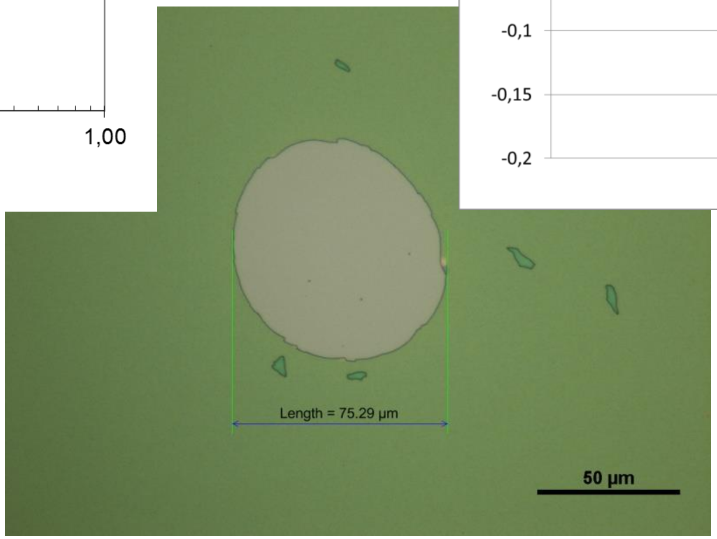
Consistent SiN removal BUT slow process

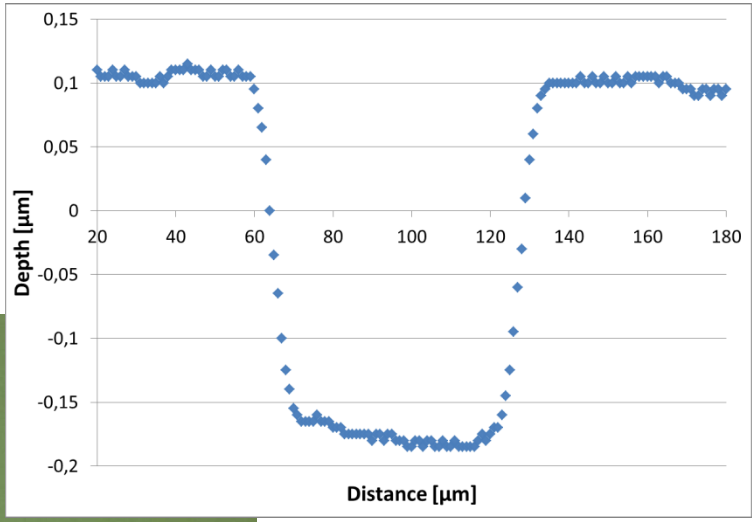
Results SiN on MAM / ps 1064nm



- **Step 1: power scan / single pulse**
  - To determine the ablation threshold of the SiN on MAM
  - Find threshold for damage of the sub layers
  - To see the behavior of ablation mechanism(s) as function of laser pulse energy







Threshold SiN removal 64 mJ/cm^2

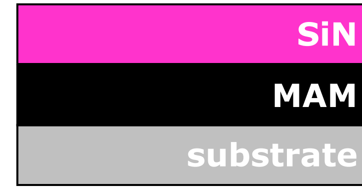
MAM micro-cracks above 150 mJ/cm^2

Photomechanical ablation

Large particles (debris)

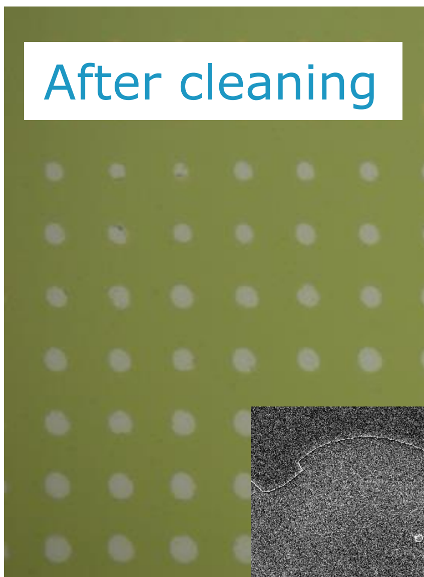
Holst Centre

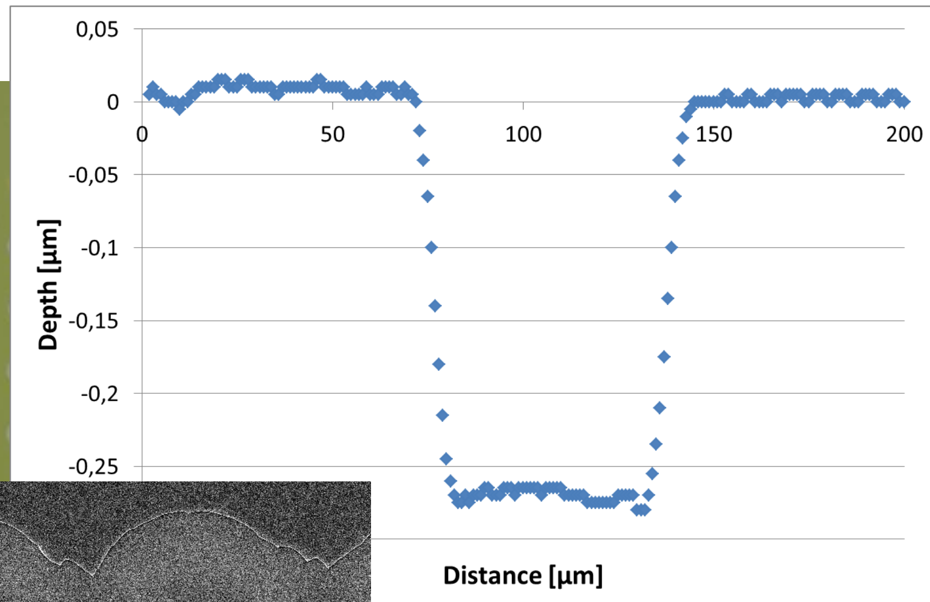
Results SiN on MAM / ps 1064nm

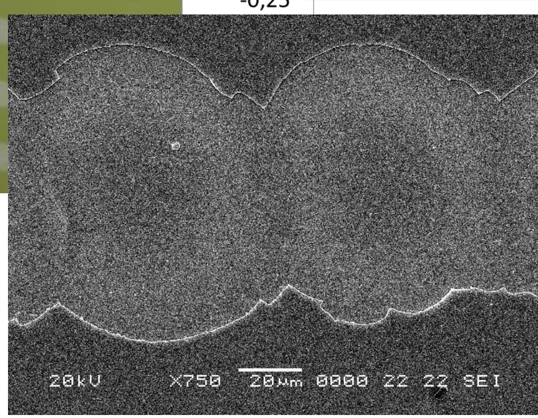


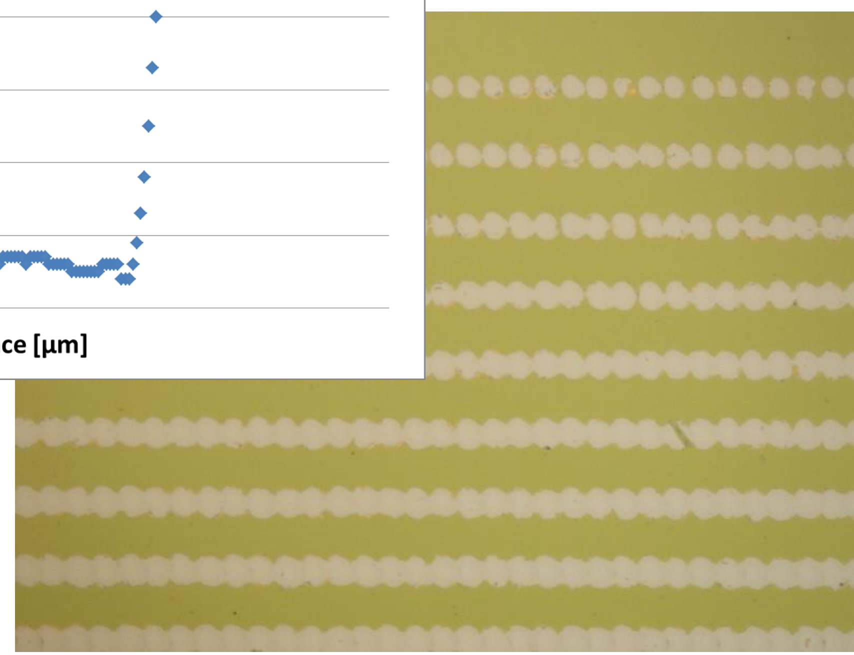
- **Step 2: photomechanical process optimization**
  - Complete SiN layer removal without introducing damage to the underlying layer
  - Large particles: cleaning method needed: e.g. N_2 blowing

Consistent SiN removal AND fast process

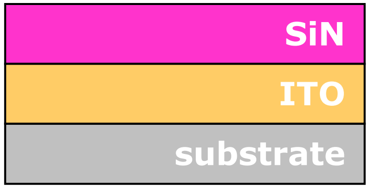








Results SiN on ITO / ps 355nm



- **Step 1: power scan / single pulse**
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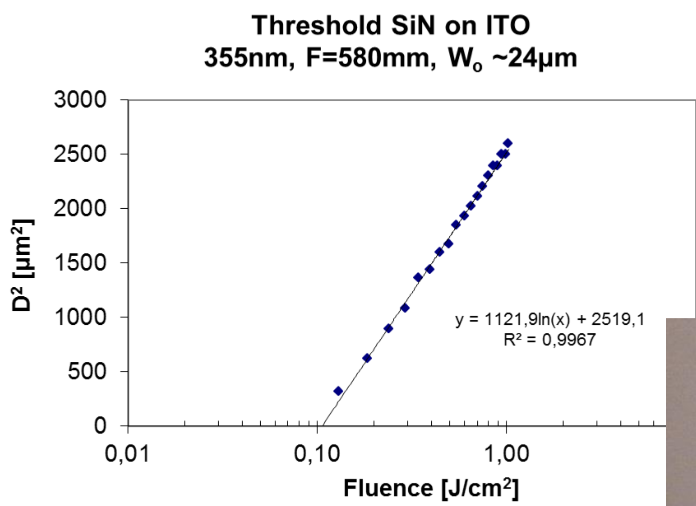
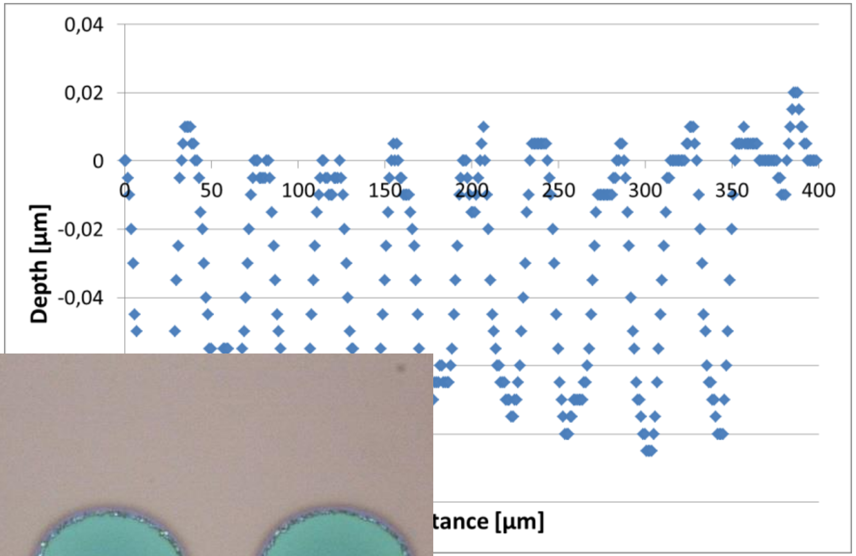
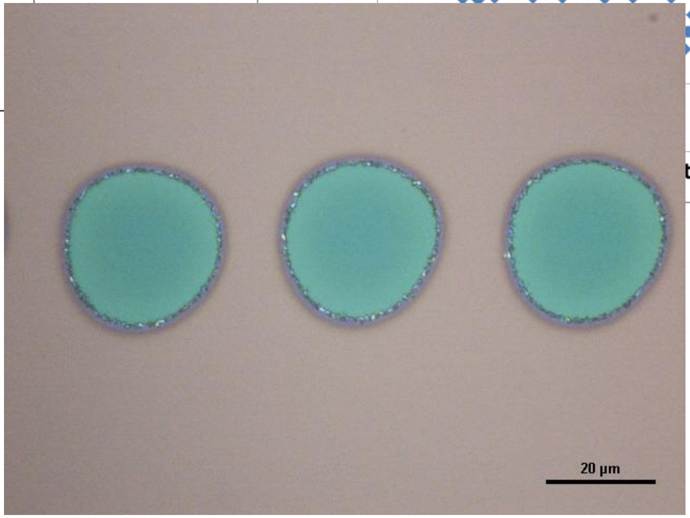
  - Find threshold for damage of the sub layers
  - To see the behavior of ablation mechanism(s) as function of laser pulse energy





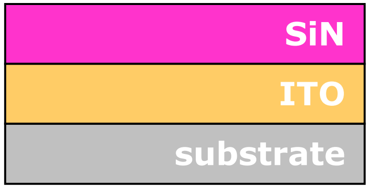


Threshold SiN removal 106 mJ/cm²

Challenging to remove the SiN layer completely

Photo-chemical assisted ablation over complete fluence range

Results SiN on ITO / ps 1064nm



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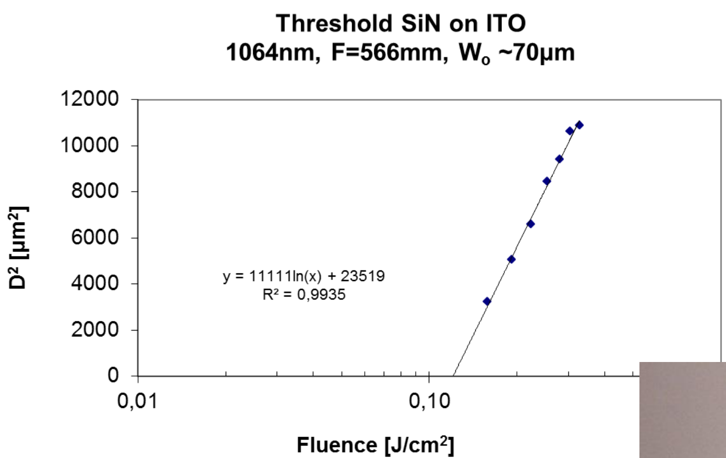
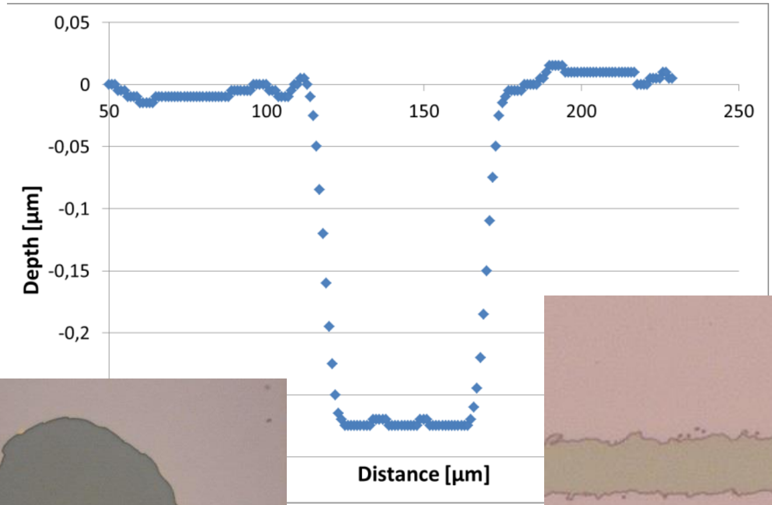
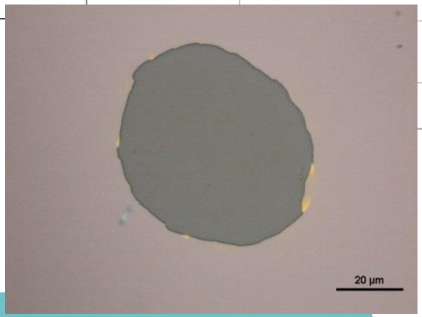
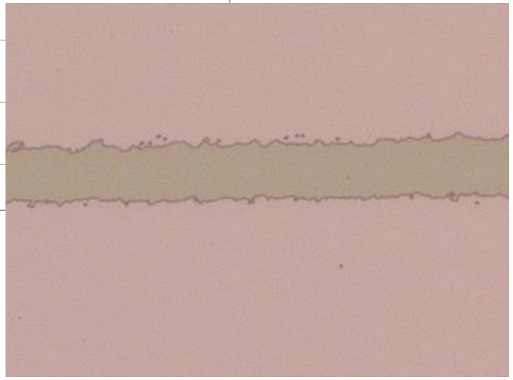




Threshold SiN removal 120 mJ/cm^2



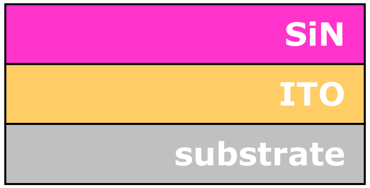


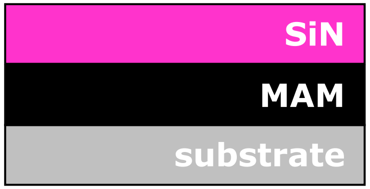
Photomechanical assisted ablation of SiN on ITO, providing a clean bottom interface

Complete SiN removal
No ITO damage

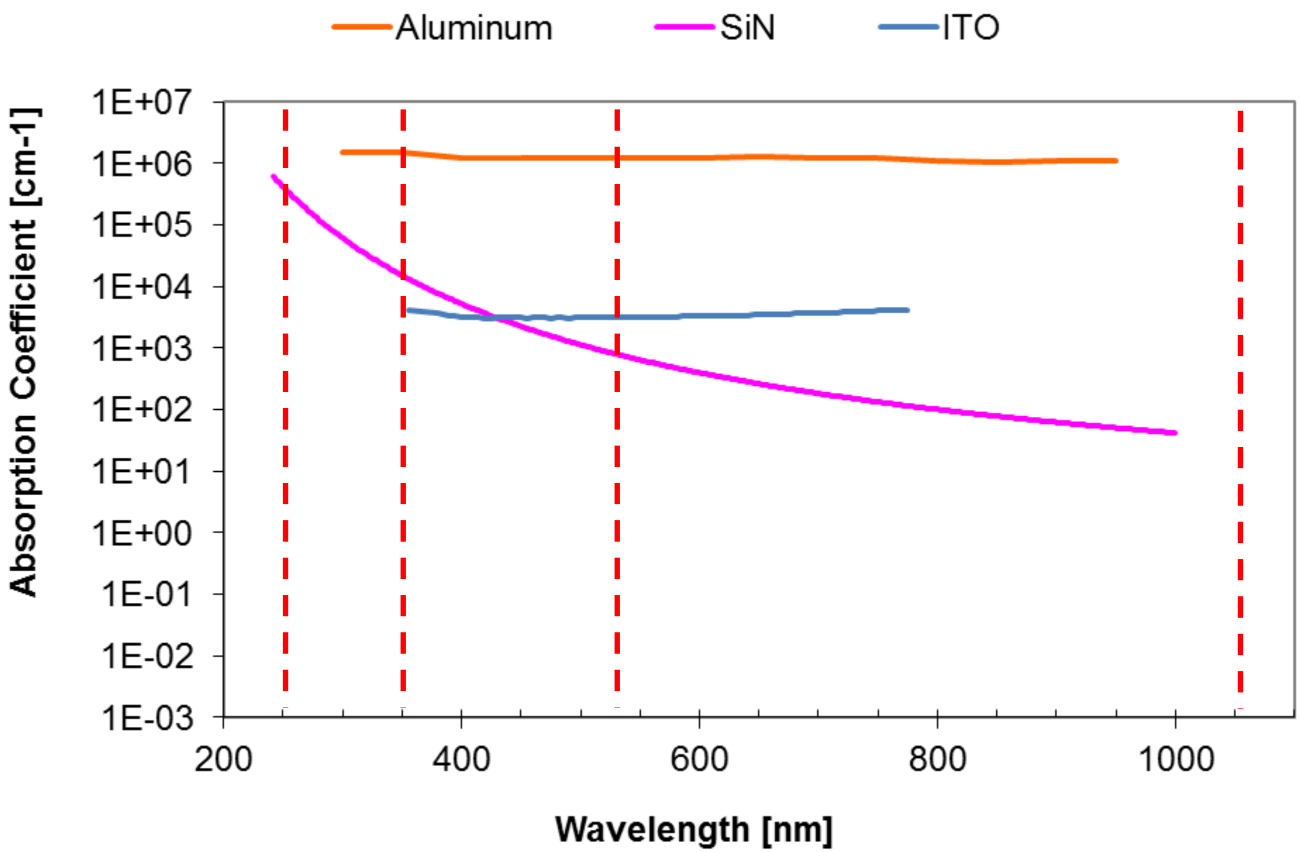
Discussion

- **Not always beneficial to select a laser wavelength which shows the highest absorption for the (inorganic) layer to be removed.**





Photomechanical process selection



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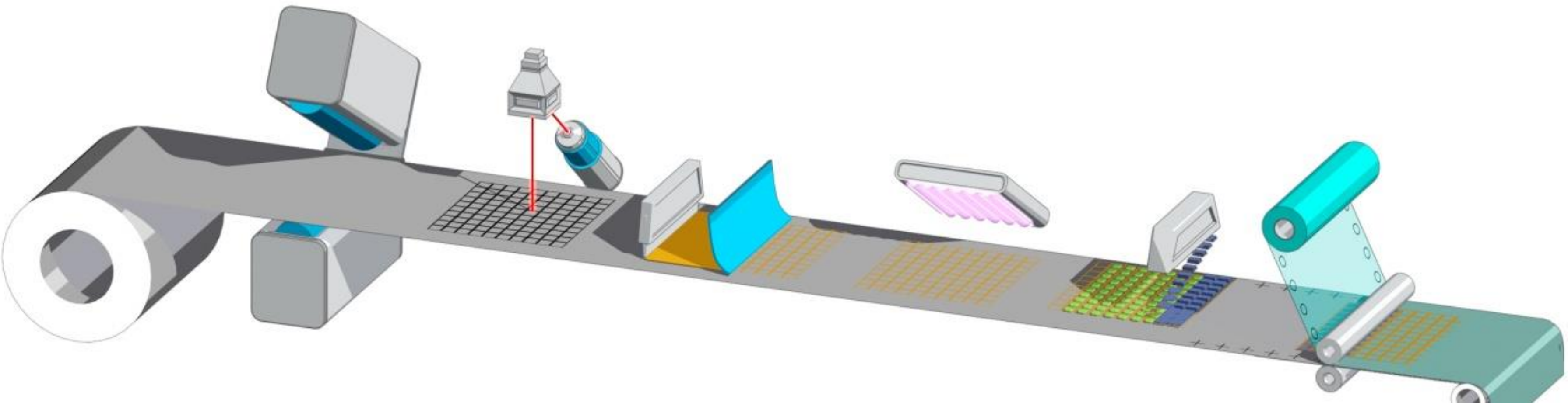

- **Influence of laser wavelength and pulse energy on the ablation mechanism**
- **Photomechanical versus photochemical assisted thin-film removal**

Acknowledgement

Fledderus Henri, Mandamparambil Rajesh, Yakimets Iryna

Hoegen Thomas

Naithani Sanjeev, Schaubroeck David