Laser Beam Positioning for Semiconductor Device Processing

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Goals

- turn-key industrial grade laser workstation
- high-speed high-accuracy beam positioning
- ± 1 µm accuracy over a 10x10 mm² field
- front and backside laser processing
- establish process flow for laser structuring

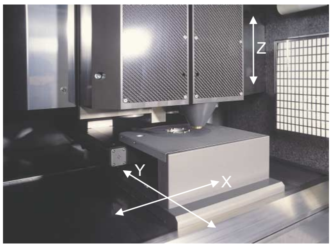
Motivation

- apply laser structuring in device fabrication
- structurize chemically inert and hard materials
- drill microholes into SiC and sapphire
- look for alternative to conventional lithography and plasma etching

Laser Workstation

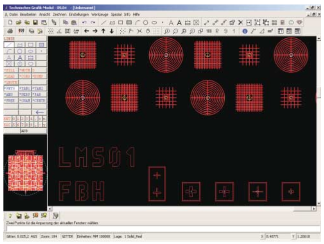
- class 1 laser safe micromachining tool
- Nd:YAG, 355 nm, 4.5 W, < 30 ns, 100 kHz
- air bearing XY stage, max. speed 20 m/min
- high-speed galvanometer beam positioner
- open-frame vacuum chuck up to 6” diameter
- vision system for high alignment precision
  - integrated pattern recognition
  - automated beam alignment
  - front-to-frontside and front-to-backside

Laser workstation ILS 500 Air.



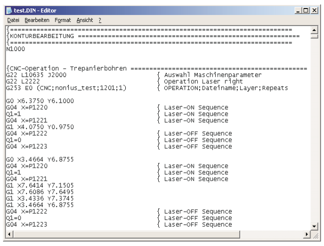
XY stage with open frame wafer chuck.

Process Flow



1. import wafer layout into GRAFFY© software
   - CAD data
   - GDSII, DXF etc.

2. attach technology parameters



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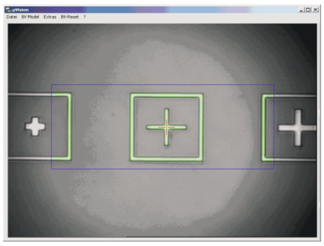
{==========================================================================
{KONTURBEARBEITUNG ========================================================
{==========================================================================
N1000


{CNC-Operation - Trepanierbohren ==========================================
G22 L10635 J2000                          { Auswahl Maschinenparameter
G22 L2222                                 { Operation Laser right
G253 E0 (CNC;nonius_test;1201;1)          { OPERATION;Dateiname;Layer;Repeats

G0 X6.3750 Y6.1000
G04 X=P1220                               { Laser-ON Sequence
Q1=1                                      { Laser-ON Sequence
G04 X=P1221                               { Laser-ON Sequence
G1 X4.0750 Y0.9750
G04 X=P1222                               { Laser-OFF Sequence
Q1=0                                      { Laser-OFF Sequence
G04 X=P1223                               { Laser-OFF Sequence

G0 X3.4664 Y6.8755
G04 X=P1220                               { Laser-ON Sequence
Q1=1                                      { Laser-ON Sequence
G04 X=P1221                               { Laser-ON Sequence
G1 X7.6414 Y7.1505
G1 X7.6086 Y7.6495
G1 X3.4336 Y7.3745
G1 X3.4664 Y6.8755
G04 X=P1222                               { Laser-OFF Sequence
Q1=0                                      { Laser-OFF Sequence
G04 X=P1223                               { Laser-OFF Sequence
```

3. generate CNC code with GRAFFY© postprocessor

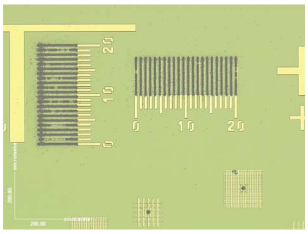


4. define alignment marks
   - wafer (pre-) alignm.
   - test field fine alignm.

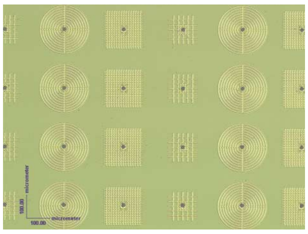
5. start laser treatment

Positioning Accuracy

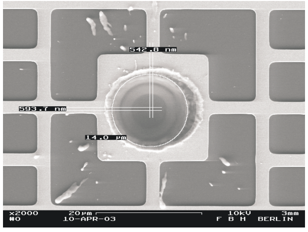
- different target structures realized
  - deviations easily estimated by optical microscopy
- beam positioning accuracy of ± 1 µm achieved
  - proven over 10x10 mm² testfield and 2” wafer
  - front-to-frontside and front-to-backside alignment



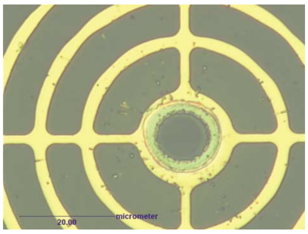
Silicon target with nonius structures scribed with the laser (front-to-frontside alignment). The deviation is X+1 µm and Y+1 µm.



Silicon target structures hit by single laser pulses each (front-to-frontside alignment). The deviations center-to-center are 1 µm.



SEM image: Silicon target hit by a single laser shot. The front-to-frontside alignment accuracy over a 2” wafer is ± 1µm.



Sapphire target hit by a single laser shot (front-to-backside alignment). The deviation center-to-center is X-0.4 µm and Y+0.4 µm.

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