DESIGN AND FABRICATION OF SENSORS ON FIBERS

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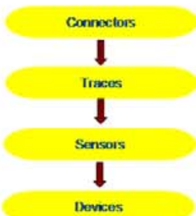
MOTIVATION AND OBJECTIVE

Parameters within a composite structure can be obtained by fabricating micro-sensors on individual fibers. The objective of this study is to implement Smart Preforms with a large population of integrated sensors to measure process as well as in-service conditions. The sensors will be fabricated using microfabrication techniques which ultimately will allow integration of passive and active devices into the structure. The major challenge is to develop the fundamental understanding of lithography on round surface and to implement a continuous fiber based microfabrication process.

APPROACH

- To design and fabricate connectors to link fiber sensors with external DAQ
- To design and fabricate connections (traces) between the connectors and sensors
- Develop process and in-service health sensors on fibers
- Create passive and active devices on fiber



MICROFABRICATION PROCESS OUTLINE

Standard procedure

- **Mask making**
- **Lithography**

1. Coat with photoresist (spin coat and dry)
2. Softbake on hotplate
3. Expose to UV light
4. Hardbake
5. Develop

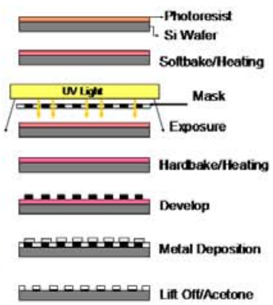
- **Metal deposotion**
- **Remove unwanted metal (lift-off)**

New procedure

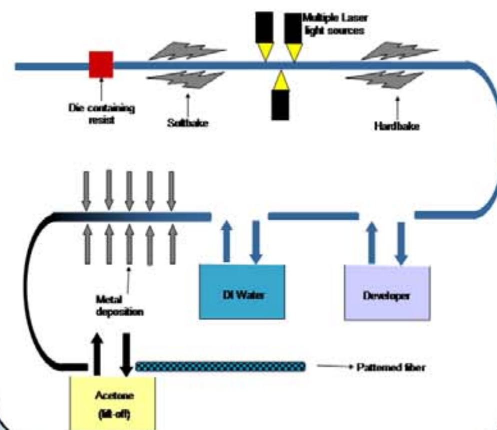
- **Lithography**

1. Apply photoresist using a cross-head frame (INSTRON)
2. Softbake in oven for longer duration
3. Laser patterning
4. Hardbake
5. Develop

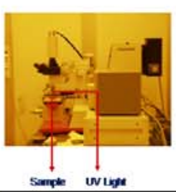
- **Metal deposition**
- **Remove unwanted metal (lift-off)**



THE CONTINUOUS PROCESS



LITHOGRAPHIC TECHNIQUES

STANDARD MASK ALIGNER	LASER LITHOGRAPHY
- Flat glass emulsion mask plates placed in between UV light source and sample - Pattern transfer is 1-dimensional	- Small spot size of light - Can work without emulsion mask - Can have more than one light source for multi dimensional pattern transfer - Power of source can be easily adjusted according to thickness of resist
	

COATING WITH PHOTORESIST

Uniformity of layer depends on

- Viscosity of Photoresist (lower viscosity favored)
- Speed of movement of die along fiber

Setup developed for coating

Figure 1:
125 μm fiber coated with photoresist of high viscosity

Figure 2:
125 μm fiber coated with photoresist of lower viscosity

PHOTOSENSITIVE MATERIAL

Figure 1

Figure 2

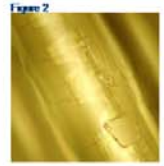


FIGURE 1: Photoresist pattern transferred with standard micro fabrication techniques onto a silicon wafer

FIGURE 2: Photoresist pattern transferred using new coating method and standard lithographic techniques onto surface of optical fiber

Reasons for distortion which are the issues currently being tackled

- **Non uniform heating of resist**

Reduced by using cylindrical heater element for softbaking as shown in figure

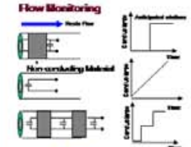
- **Dispersion of light within fiber**
- **Flat patterns transferred onto rounded substrate (fiber)**

Both reduced by using laser light beam instead of standard procedure of lithography (emulsion mask + UV light)

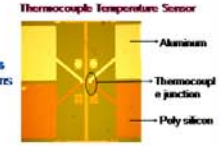
SENSOR TYPES AND PRELIMINARY DESIGNS

Flow Monitoring Sensors
Monitoring Micro-Flow Parameters
Piezoelectric Strain Sensors
For residual Stress Measurement
Thermocouple Temperature sensors
For monitoring local exothermic reactions

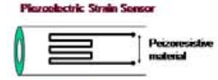
Flow Monitoring



Thermocouple Temperature Sensor



Piezoelectric Strain Sensor



ISSUES
- Reliability of devices within composites
- Interconnection of multiple sensors

APPLICATIONS
- Local health monitoring in composites
- Beginning of 'Smart' Structures

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