Energy Efficiency and Renewable Energy Nanomanufacturing Initiative

Energy efficient shape control and change of flexible substrates

Benefits to the Nation
- Energy efficient thin film processing
- Controllable shape for inflatable structures and electronics

APPLICATIONS
There are numerous applications in energy production, photovoltaics, outer space mirror systems, and energy efficient thin film production.

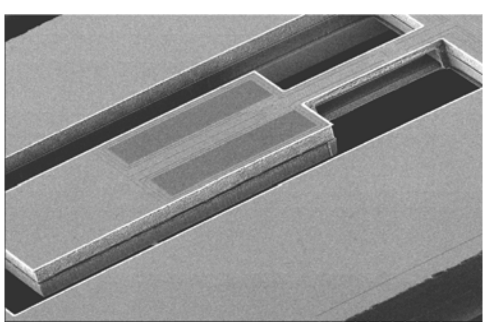
For flexible photovoltaics and/or inflatable structures.

There is an inherent advantage in electronics and optics functionality on surfaces which is not on a planar surface. However, new approaches and technologies for fabricating surfaces which have a three-dimensional shape are needed.

Active and reversible shape control of flexible and inflatable structures will be made possible by complex stress inducing patterns to the structure. Stress inducement can be realized in-situ with stress strain controlling thin film piezo actuation on flexible organic substrates

Realizing the high temperature processing of inorganic electronics and thin films on temperature sensitive organic substrates is possible using ORNL's pulse thermal processing (PTP) technique

This technique is a revolutionary enabling technology for functionalizing nanomaterials due to its ability to control diffusion at the nanometer scale. The inherent characteristics of this technology (high heating rates, short processing times and larger area processing) enables unique thermal annealing capabilities such as processing thin-films on temperature sensitive substrates such as polymers. It has been demonstrated that utilizing solid phase crystallization (SPC) PTP is able to crystallize amorphous silicon thin films.



Piezoelectric films on a micro-mechanical system to control the deflection of a cantilever

UT-BATTELLE

Project Description

Goal: Realizing a surface with embedded electronics and controllable surface shape.

Issues and Approaches: Realizing the high temperature processing of inorganic electronics and thin films on temperature sensitive organic substrates and controlling the shape

Thin piezoelectric films can be designed in lateral form and thickness to create non-linear stress inducements as calculated with the above mentioned mathematical model. The piezoelectric films induce the stress over a large area instead of certain points of singularity. Therefore, singularities can be totally avoided and the shape of a focal array will be optimized. Figure 2 shows a piezoelectric film for controlling the deflection of micro-mechanical system. A complex arrangement of non-rectangular films of flexible structures can induce complex stress patterns to create a special shape.

The piezoelectric films have no mechanical moving parts and represent therefore a light weight structure by itself.

The project will bring materials science, mechanical and electrical engineering, as well as adhesion and chemical science together to create these new and special structures.

ORNL's pulse thermal processing (PTP) technique is a revolutionary enabling technology for functionalizing nanomaterials due to its ability to control diffusion at the nanometer scale. The inherent characteristics of this technology (high heating rates, short processing times and larger area processing) enables unique thermal annealing capabilities such as processing thin-films on temperature sensitive substrates such as polymers. It has been demonstrated that utilizing solid phase crystallization (SPC) PTP is able to crystallize amorphous silicon thin films.

The PTP technique utilizes a unique high density plasma arc lamp, which is the most powerful radiant arc lamp in the world. Power densities on the order of 20,000 W/cm^2 can be achieved over broad areas (currently up to 1,000 cm^2) and can be pulsed in 1 millisecond. The plasma arc lamp power densities are reaching the lower tier of that of lasers, but it is a fundamentally different process. Due to the large area processing capability, a one dimensional thermal field is established (in the z-direction) versus the three dimensional thermal fields customary with laser processing. The large area processing ability of PTP provides more uniform microstructures and minimizes residual stresses which are inherent difficulties associated with laser (rastering) processing. These unique characteristics of PTP ultimately allow large area processing of thin-films or nanoparticle systems on temperature sensitive substrates such as polymers, which cannot be done with conventional technology.

The PTP technique is a pervasive technology that could be utilized in a multitude of other defense applications, such as thin-film transistors for flat-panel roll-up flexible displays, thin-film batteries, multifunctional flexible sensors, thermoelectrics, photovoltaics and other such devices. This technology has been proven in many arenas; from bulk sheet fabrication to next generation nanoparticle magnetic media applications. The high power densities, short processing time and broad processing areas make it an ideal manufacturing tool for high throughput low cost applications.

Critical Tasks

- *Modelling the complex geometry of piezoelectric films for meeting the shape requirements*
- *Depositing piezoelectric thin films*
- *Processing thin films on organic substrates using PTP*
- *Developing suitable PTP parameters*
- *Connecting the piezoelectric films to control units*

FOR ADDITIONAL INFORMATION, PLEASE CONTACT

Claus Daniel

Materials Science and Technology Division
Oak Ridge National Laboratory
Phone: (865) 241-9521

Co-PIs:
Ron Ott (MSTD)
Panos Datskos (ESTD)\
Craig Blue (MSTD)
Edgar Stach (UTK)
Hans DeSmidt (UTK)