Construction of Microplasma Test Array

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Primary CNF Tools Used: ASML 300C gamma coat / develop tool, SC4500 deposition

Abstract:

Since 2016, WildSpark Technologies LLC has been working to develop and commercialize microplasma devices. Microplasma devices create and manipulate small regions of plasma from gas, solid, or liquid feedstock. These devices show promise for novel applications in electron devices, displays, medical devices, and flow control. Our lean and agile team uses the resources at the CNF to rapidly test concepts and construct prototype devices for test. In this report we discuss our efforts to build a system of electrodes and substrate stack to probe material and physical parameters which are used as building blocks for more complicated devices. The physical data extracted from these prototype devices is used to calibrate models used in multiphysics simulation to predict device performance in real world applications.

Summary of Research:

We created patterns of electrodes on varying substrate materials. These patterns formed microplasma actuator elements and were windowed across a range of dimensions and physical designs. We then tested the devices using semiconductor parameter analyzers and were able to directly measure — for the first time — our microplasma cells in action. Our company constructed several devices with different material stacks and substrate composition to assess the impact of material parameters on performance. The electrical test data was used in combination with physical simulation in order to isolate physical parameters, in particular the Fowler-Nordheim tunneling equation coefficients for the material system.

We were concerned about the ability of our test devices to operate under high power densities for a long period of time. The results of these experiments demonstrated an ability to operate at power densities exceeding $0.5W/mm^2$ for several minutes without degradation. This result exceeded our expectations and allows us to consider designs and power densities that we previously thought to be unattainable. While there are few comparable technologies in the literature, we believe this represents a milestone in terms of device endurance.

We chose CNF as a fabrication facility primarily because of the availability of the ASML 300C 248 nm stepper and gamma coat / develop system. Our work requires us to pattern very fine structures with tight tolerances for both critical dimension (CD) and registration. It is very difficult to find production 248 nm lithography tools available for use by small businesses and our work would not be possible without these tools.

We extensively used the SC4500 deposition tools in order to deposit titanium electrodes as well as some proprietary surface coatings to our electrode / substrate sandwiches. Interconnects and bond pads were constructed using a metal liftoff technique with aluminum deposition.

Our future work at CNF will include further refinements of our test arrays to gain new insight into microplasma device physics and eventually to produce prototype products based on this knowledge.

References:

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