Microhollow cathode discharges on silicon devices

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DC Microhollow cathode discharges have been produced on silicon platforms through different gases such as He, Ar and N_2. Silicon cathodes were investigated first, but induced many instabilities. Other materials deposited on the silicon were also tested and show much different behaviours. The microplasmas were optically and electrically characterized. The microreactors were also characterized after operation by SEM observations. Some new geometries were also tested to allow the injection of higher currents and powers (up to 1 W per microdicharge). By inversing the polarity, a quite different behaviour was evidenced that will be discussed as well.

1. Introduction

DC Microhollow cathode discharges (MHCD) were first introduced in the mid 90's [1]. Due to their dimension and their large surface to volume ratio, the produced microplasma remains cold and can stably operate at atmospheric pressure in the normal regime provided the cathode area is not fully utilized [2]. Microhollow cathode discharges on silicon platforms were first studied by J. G. Eden's group [3]. Silicon processing intensively developed for microelectronic devices offers many opportunities to design new, original and efficient devices to produce high density microplasmas.

An array of 1064 microplasmas using an etched silicon cathode could be completely ignited [4]. Unfortunately, the device operation is unstable and produces many current spikes that significantly damage the microcavities and lead to device failure. The mechanism responsible for this unstable operation and short lifetime was investigated [5]. In this paper, we discuss different possibilities to enhance the stability of microdischarges made from silicon wafers.

2. Experiment

A microreactor is schematically represented in Fig. 1. A ballast resistor is used to limit the current.

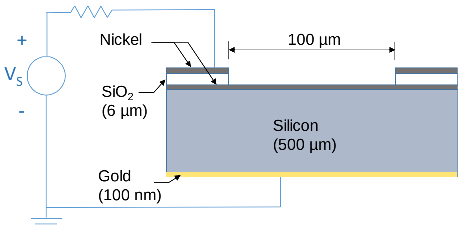

Figure 1: Schematic of a microdischarge reactor

In this particular configuration, the silicon cathode was covered by a metal thin film (nickel in this example). More than 15 individual process steps are necessary to create such a structure. The devices were then tested in 3 different gases: He, Ar and N_2.

3. Results

An example of a microdischarge operating in Argon (150 µm diameter cavity) is shown in Fig. 2. A very stable operation is obtained using the configuration shown in Fig. 1. The lifetime of the microreactor with a confined cathode is much longer when using nickel than with silicon. Other materials were also investigated. Interestingly, the same type of instability is obtained using a tungsten cathode as with silicon. Modifying the geometry, it was possible to inject a total power of up to 40 W in an array of 38 argon microplasmas.

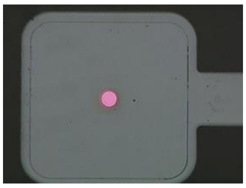

Figure 2: Single microdischarge operating in Argon.

In the case of inverted polarity, a bright spot appears in the middle of the cavity.

4. References

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