Impedans' Semion provides key ion energy measurements required for the development of Vertical Graphene through PECVD process

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Introduction

The Impedans 'Semion' is an advanced ion energy analyzer, offering crucial insights into various process parameters such as average ion energy, ion flux, and ion energy distribution functions. These insights are crucial for optimizing and controlling processes at the substrate level. The Semion finds application in diverse areas, including plasma-assisted deposition techniques like ALD, PECVD, and HiPIMS.

A recent publication from Science Direct underscores the utility of the Impedans Semion system in the growth of vertical graphene using PECVD. Semion measurements played a key role in demonstrating how low-energy ions in plasma contribute to the nucleation and growth of vertical graphene by interacting with the surface.

Experimental setup

Vertical graphene (VGs) was synthesized in a 13.56 MHz RF-ICP reactor by employing CH4 gas under different conditions, including various substrate temperatures, deposition times, pressures, and the use of diluent gases (Ar or H2). The experimental setup of the plasma-enhanced chemical vapor deposition (PECVD) reactor used in this study is depicted in Figure 1. A 14 μm thick copper foil was employed as the substrate, placed on a graphite holder during deposition to maintain a substrate temperature of 630 ℃. After the deposition process, the samples naturally cooled to achieve room temperature.

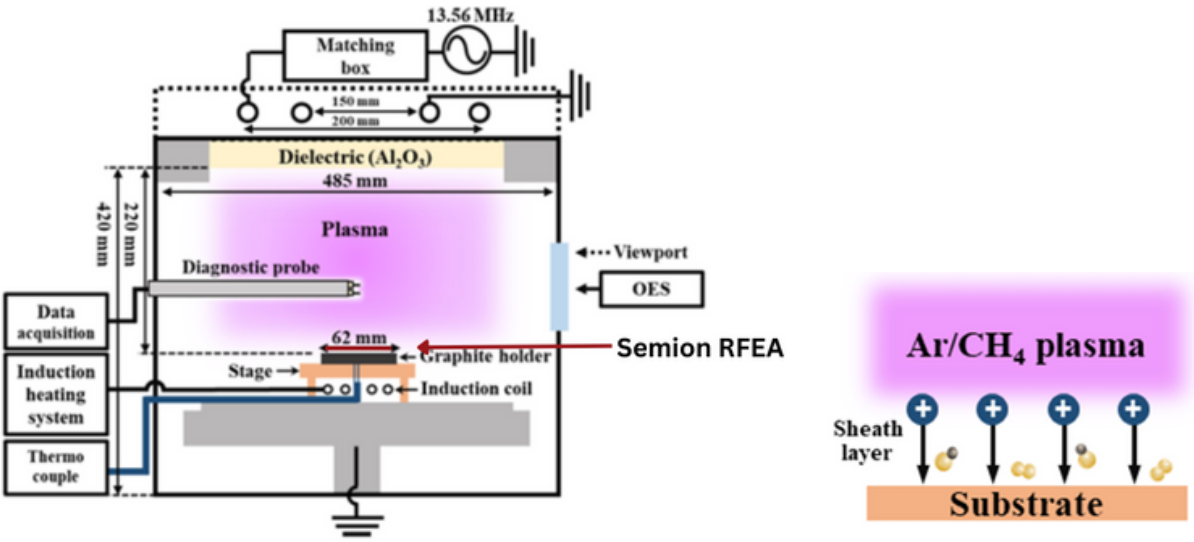

Figure 1 Figure 1 (Left) Schematic of the experimental setup and measurement system, (Right) Illustration of ion bombardment on substrate.

Results

The ion energy distribution function (IEDF) was acquired utilizing a retarding field energy analyzer (Semion, Impedans Inc.), positioned on the graphite holder to understand the relation between VG deposition and ion energy within different plasma conditions.

Figure 2(a) displays the Ion Energy Distribution Functions (IEDFs) plotted against increasing pressure. With pressure increasing from 35 to 240 mTorr, the peak energy of the IEDF decreased from 7.8 to 2.0 eV, accompanied by a decrease in peak height. The growth rate of VG depends on the ion bombardment energy and radical density. Decrease in growth rate with increasing pressure can be explained by a decrease in number and energy of ions with the etching effect of hydrogen. These findings suggest that ions play a significant role in VG growth, and VG growth is improbable in the absence of ions.

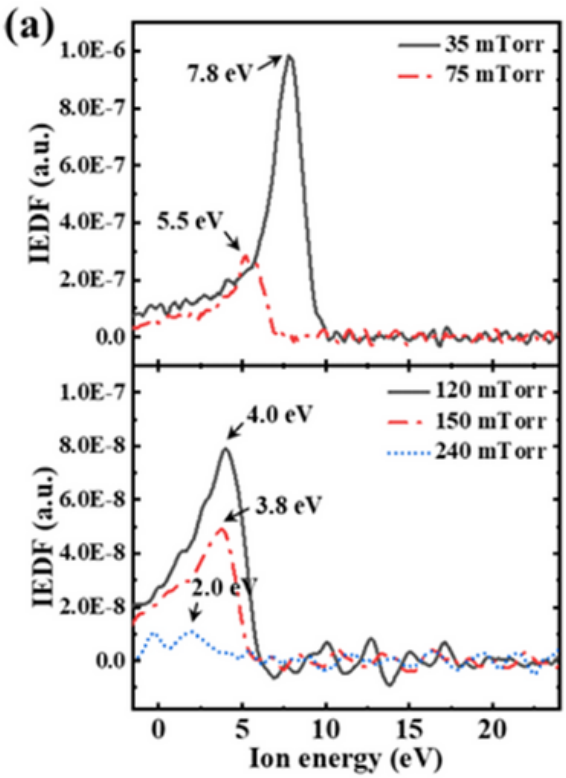

Figure 2 (a) IEDF as a function of the pressure in Ar/CH4 plasma.

By controlling the ion density and energy, VG nucleation was successfully achieved, even in H2/CH4 mixtures even though the growth rate was lower than that with Ar/CH4 mixture. Peak ion energies with respect to different pressure in both cases are shown in figure 3.

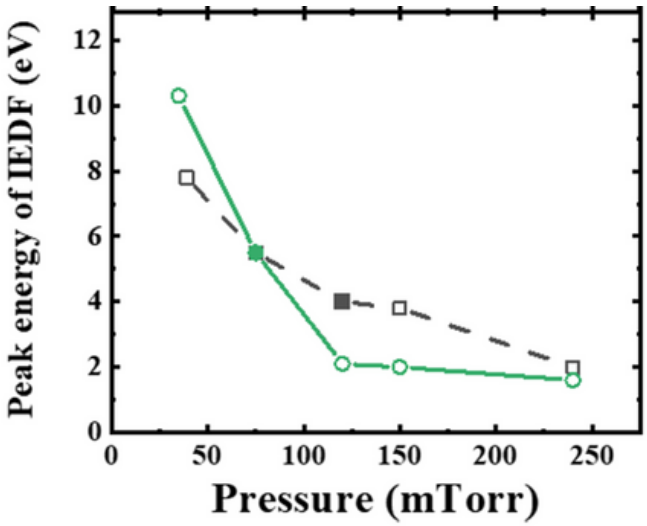

Figure 3 Peak energy of IEDF as a function of the pressure at an ICP power of 1 kW in the Ar/CH4 plasma (shown in black) and ICP power of 1.6 kW in the H2/CH4 plasma (shown in green).

Summary

Utilizing Semion measurements, researchers observed ion dynamics near the substrate within the PECVD reactor using Ar/H2 and CH4 gas plasma conditions. The findings underscore that ion properties significantly influence not only the growth but also the nucleation of Vertical Graphene (VG). Experimental observations also revealed VG nucleation and growth at ion energies below 10 eV.

Impedans Semion provide key measurements like ion energy distribution functions which are required to understand the nucleation and growth process of nanostructures. Consequently, researchers can exert control over the morphology and crystallinity of the deposited structures.

To know more about Impedans Semion RFEA click here.