Visualizing Evactron® Turbo Plasma™ Cleaning in nanoflight® Movies

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XEI has recently invented a new plasma generation technology with RF external hollow cathode excitation. This new Evactron E50 plasma cleaner operates from a lower base pressure compared to previous models and rapidly removes most hydrocarbons from a vacuum chamber. At turbo pump pressures, Evactron cleaning becomes faster and the downstream plasma afterglow spreads throughout the chamber, removing contamination and significantly shortening pump down time, allowing for high throughput of sample processing and analysis [1].

Previously hydrocarbon removal has been monitored by means of quartz crystal microbalances [2] and residual gas analysis [3]. For the first time the process of plasma cleaning has been recorded as it happens, not simply before and after images. nanoflight® SEM movies are a revolutionary new way to visualize structures of the micro-world, combining the particular way of acquiring colored images in the SEM with the ability to move a virtual camera in eight degrees of freedom around the specimen [4]. For high-end imaging and 3D work, a TESCAN MIRA3 Field-Emission SEM was equipped with a SmarAct 8 axes piezostage, a multi-detector setup made by Pointelectronic and an Evactron E50 plasma cleaner.

The nanoflight® movie of hydrocarbon removal shows two sequences identical in movement: the first one an overview of the deposited hydrocarbon layers, four fields with different thicknesses, made by growing the layers for 1 / 2 / 4 / 8 hours at 2kV and a beam intensity of 18 in the MIRA3. The second movie has the same movements but in-between each of the original 577 movie frames (25 frames needed per second of film) a manual cleaning cycle with the Evactron E50 was performed with 25 watts ignition and 25 watts of plasma for 15 seconds. The thickest HC layer - ca 1000 nanometer - was finally removed with a rate of one nanometer per 9 seconds of plasma. Image analysis of the resulting movies is used to quantify the degree of hydrocarbon removal during the cleaning process.

Typically, vacuum chambers can be cleaned with the Turbo Plasma™ Cleaning process at turbo molecular pressures of 10^{-2} to 10^{-3} Torr with cleaning times of 2 - 10 minutes to maintain pristine conditions, and returning to normal operating pressures in < 20 minutes. Current users of Evactron plasma cleaners report significant reduction in pump down time after using Evactron De-Contaminators as well as easier maintenance of the pristine state of cleanliness of their SEMs, CDSEMs, FIBs, TEMs and UHV chambers.

References:

[1] E. Kosmowska, M. Cable, B. Armbruster and R. Vane, Microsc. Microanal. **23** (Suppl. 1) (2017), p. 74.
[2] C.G. Morgan, M.M Gleason and R. Vane, Microsc. Microanal. **13**(2) (2007), p. 1736.

[3] R. Vane and M. Cable, Microsc. Microanal. **24** (Suppl. 1) (2018), p. 1152.
[4] http://www.nanoflight.info

Figure 1. Tescan MIRA3 FESEM equipped with an Evactron plasma cleaner.
Figure 2. The standard microscope stage is replaced with a SmarAct 8 axes piezostage for full motion control.

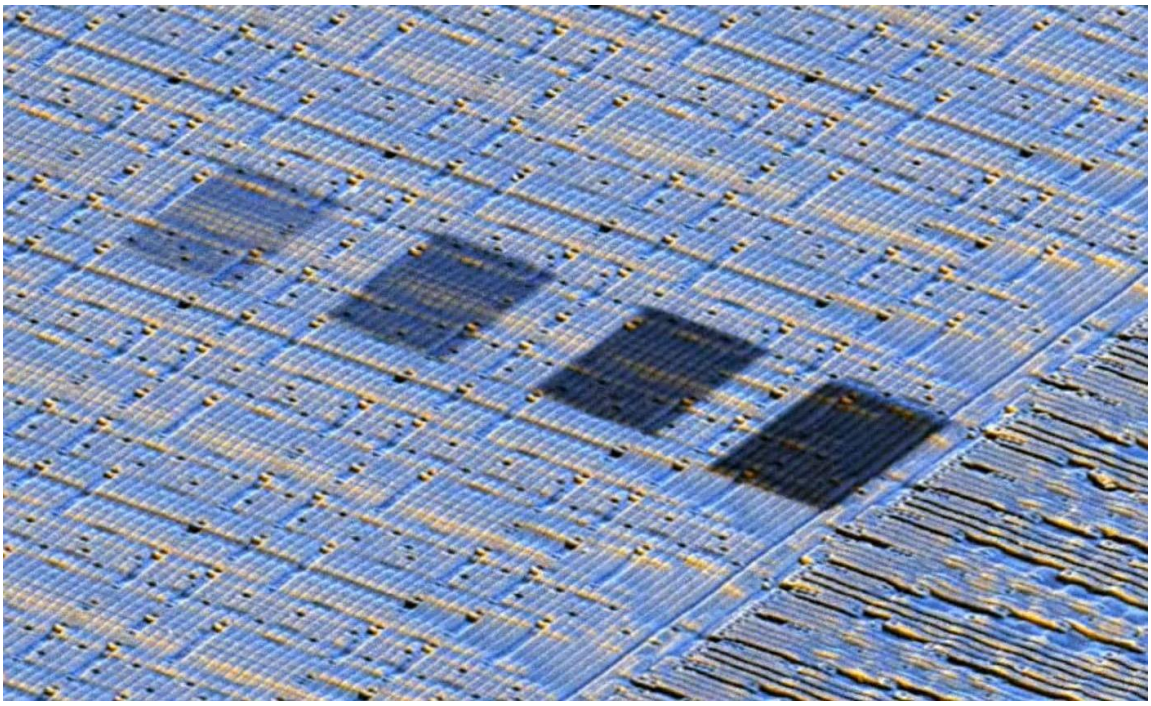

Figure 3. Regions of increasing hydrocarbon contamination were scanned onto the silicon wafer with the thickest deposit of ~1000nm at the right. nanoflight® movies recorded the sequence of hydrocarbon removal rate of one nanometer for every nine seconds of plasma exposure.