Monday Afternoon, November 10, 2014

Vacuum Technology
Room: 303 - Session VT-MoA

Vacuum Measurement, Applications of UHV and Ultraclean Processes
Moderator: Joe Becker, Kurt J. Lesker Company, Bob Garcia, SAES Getters

2:00pm **VT-MoA1 A Capacitance Diaphragm Gauge with 10 mTorr Full Scale**, ***Martin Wüest***, INFICON Ltd., Liechtenstein, *P. Björkman, J. Bäckman*, INFICON Ab, Finland

Etching of semiconductors chips is a complex process and there are critical process steps that tend to go to lower pressures. At lower pressures scattering at the residual gas is reduced which allows obtaining narrower and deeper vias, important for three-dimensional chip structures. Many etch process pressures today are around 1 Pa and use a 13.3 Pa full scale CDG in the second measurement decade where accuracy is already lower. We use ceramic technology to build pressure sensors that measure an elastic deformation of a diaphragm under the feeble pressure forces while being highly resistant to etch chemistries. Improvements to the manufacturing process now allow us to manufacture thinner, highly elastic, leak tight membranes. We now have developed a heated capacitance diaphragm gauge with 1.33 Pa (10 mTorr) full scale. The low full scale is achieved by the deflection of a thinner membrane and focus on noise reduction and not by electronic amplification. We will present pertinent performance parameters.

2:20pm **VT-MoA2 What if Saving Energy become Important on Bayard Alpert Hot Ionization Gauges?**, ***Simon Naef***, INFICON Ltd., Liechtenstein

Hot ionization gauge have been on the market for decades and many refinements have been made over the time. A lot of common knowledge how to build a stable, sensitive, and accurate BA-gauge is recorded. How about overall power consumption and the energy efficiency of hot ion gauges? The topic of energy conservation has been neglected so far.

The saved energy per gauge is not essential, but on the global view the power consumption can be reduced significantly. Even the high energy consuming semiconductor industry tries to reduce their footstep, since 80% of energy used in this industry is manufacturing and transportation.

How can that are achieved? Integration and miniaturization is way used in the past. So there are many compact hot ion gauge designs available on the market today, which use obviously less energy than larger full-size hot ionization systems. But what is drawback of going small and is worth going small?

On one hand the heated cathode defines mainly the power consumption, which is based on the electron emissivity of the surface material used and the resistance of the used wire material. On the other hand the sensitivity of BA-gauge is based on the geometry of the electrodes, which can be correlated to the efficiency of the gauge. Is there any option with any optimal compromise size?

3:40pm **VT-MoA6 How to Create as Less as Possible to Make the Best as Possible**, ***Norbert Koster***, TNO Technical Sciences, Netherlands **INVITED**

The field of vacuum technology is rapidly becoming a full blown industry, with parts and component suppliers, OEM manufacturers and end users (IDM). The generation of vacuum is not the goal, but the means to realize products and devices. Especially the semiconductor industry is one of the driving forces in this development, but also large scientific projects like ITER, Cern and others require a supply chain that can deliver parts that meet the requirements and certification. The upcoming introduction of EUV lithography required a change in the supply chain for manufacturers like ASML with suppliers that had to deliver vacuum qualified assemblies without any knowledge of vacuum technology.

The introduction of EUV also meant very complex vacuum systems that could not be baked anymore but with cleanliness demands that superseded the cleanliness that can be achieved with baked UHV systems. This was achieved by a rigorous cleaning and qualification process, standardized outgassing measurements and budgeting of all the parts and assemblies. To make a distinction between ordinary type of vacuum system building and this new way of making vacuum systems the phrase Ultra Clean Vacuum (UCV) was introduced. This presentation will describe how we solved a number of problems that occurred during this type of manufacturing, this includes supply chain engineering, cleaning procedures and solutions in the tool itself. This way of creating vacuum systems is now also being used by other OEM's like AMAT, KLA-Tencor who are building highly complicated metrology tools and processing equipment, while vacuum generation is not their core business.

4:20pm **VT-MoA8 Study of Potential Particle Generation by Ion Sources During EUV Mask Blank Deposition**, ***Ivan Shchelkanov***, *A.M. Lietz, J. Pachicano*, University of Illinois at Urbana-Champaign, *A. Antohe, P. Kearney*, SEMATECH, *D.N. Ruzic*, University of Illinois at Urbana-Champaign

We summarise the research accomplishments of the CPMI-SEMATECH research project "Identification of possible defect sources and particle characterisation from sources used in EUVL chambers for mask blank manufacturing". The main goal of the project is the determination of nanoparticle production (100-350 nm in size) from the ion source currently used for mask blank manufacturing in EUV lithography chambers at SEMATECH. Combination of Volumetric Laser Scattering and Surface Laser Scattering system, and Scanning Electron Microscopy (SEM) was used to develop time resolved phenomenological model of nano-particle generation inside vacuum chamber during ion beam source operation. In this project a Veeco 3cm RF ion beam source with two molybdenum grids and RF neutralizer was investigated. Stiletto Volumetric Laser Scattering system developed by INFICON together with Surface Laser Scattering system, developed at CPMI were used to detect nano-particles. This combination of laser systems was able to detect particles with the size of 100 nm and bigger. Scanning Electron Microscopy was used to track evolution of the ion source grids surface. SEM photos of the grids and polished silicon wafers on the ion beam path were used to identify and characterize nano-particles via size, shape and material. Nano-paticle generation rate by the ion beam source was measured and recommendations for the source operation are made.

4:40pm **VT-MoA9 Particle Defect Reduction in EUV Mask Blank Production Devices**, ***Amanda Lietz***, *I.A. Shchelkanov*, University of Illinois at Urbana-Champaign, *A. Hayes*, Veeco Instruments, Inc., *J. Pachicano, S. Keniley, D.N. Ruzic*, University of Illinois at Urbana-Champaign

Extreme UltraViolet Lithography (EUVL) requires reflective mask blanks, manufactured by ion beam sputtering a multilayer stack of thin films, primarily Mo and Si, onto a mask substrate. At least 40 bilayers of Mo and Si are necessary to produce a surface which has sufficient EUV light reflectivity for use in high volume manufacturing exposure tools. When contaminant particles deposit between these layers, the EUV light is absorbed or scatters irregularly, rendering the mask blank unusable. One possible source of such particles is bombardment of shields in the deposition chamber by energetic particles scattered from the ion beam and target and "overspill" of the tails of the ion beam off the edge of the target. Stainless steel shields are used to cover targets that are not in use and prevent deposition or sputtering nearby surfaces and equipment. These shields must be able to accept many successive layers of deposition without flaking and forming particles of deposited material. They also must be able to withstand ion beam overspill bombardment, while forming a minimal amount of particles.

In order to evaluate improved shield materials and surface finishes, shield samples of various treatments were placed under a broad angle ion beam and particles were collected on a witness plate. The total number of particles on the witness plates was quantified using laser scattering particle detection which was capable of detecting particles greater than 125nm in size. Etching treatments of the shields show an improvement from 13.0±.7 particles/mm2 (for untreated steel) to .022±.016 particles/mm2 (for etched steel). Shields of various materials and surface finishes were compared to determine the lowest level of particle formation

5:00pm **VT-MoA10 VTD Early Career Award: Novel Vacuum Processing of Thin-Film Photovoltaic Materials**, ***Jason D. Myers****, *J.A. Frantz, R.Y. Bekele, V.Q. Nguyen, C.C. Baker, S.C. Erwin, N.D. Bassim*, U.S. Naval Research Laboratory, *A. Bruce, S.V. Frolov*, Sunlight Photonics, *J.S. Sanghera*, U.S. Naval Research Laboratory **INVITED**

In this presentation, two different avenues of research into thin film photovoltaics will be discussed. The first part of the talk will be focused on quaternary-sputtered Cu(In,Ga)Se2 (CIGS) thin film photovoltaic devices. Current state-of-the-art CIGS devices are produced using a multistage thermal coevaporation process that has resulted in laboratory efficiencies in excess of 20%, but this process is difficult to implement at a commercial

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*** VTD Early Career Award**

scale. Our work has instead focused on developing a scalable deposition technique using RF magnetron sputtering of quaternary CIGS. The resulting films do not require post-selenization, reducing processing time and cost. We have fabricated devices above 10% efficiency using this approach, showing its promise as a production method for high-performance CIGS.

The second part of the talk will be focused on an emerging thin film photovoltaic system, FeS2. Based on its favorable bandgap, high absorption coefficient, and immense earth abundancy, FeS2 is a highly promising material for grid-scale energy production. However, no successful thin-film photovoltaic devices have been realized due to surface defect states that arise due to the cubic pyrite structure, where sulfur atoms are differentially bonded at the surface compared to the bulk; this leads to extremely low open circuit voltages and poor diode characteristics. To solve this issue, we are developing vacuum-deposited inorganic capping films to heal these defects by providing bulk-like coordination at the FeS2 surface. FeS2 films with ZnS capping layers show a significant decrease in surface state character, an important step towards efficient FeS2 photovoltaics.

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