KFM 8: Diamond I (joint session KFM/HL)

This session represents the physics, the production and applications of diamond and diamond related materials in the fields of dielectrics, electronics, high frequency techniques, GHz * THz * applications, mechanics and optics and biological applications as well. Defects in diamond have a large influence to the physical properties (e. g. NV-centers). Applications of diamond (single, poly-crystalline, UNCD, etc.) or related materials in technical systems are part of this session (Nuclear fusion applications, high frequency heating systems and material processing).

Chair: Dirk Strauss (KIT)

Time: Tuesday 9:30–12:00 Location: PHY 5.0.20

KFM 8.1 Tue 9:30 PHY 5.0.20

The ITER Diamond Window - Qualification Program Development of a Safety Important Component — •Sabine Schreck, Gaetano Aiello, Andreas Meier, Theo Scherer, and Dirk Strauss — Karlsruhe Institute of Technology, Institute for Applied Materials, Hermann-von-Helmholtz-Platz 1,

An important component of the ITER ECRH Upper Launcher system is the torus diamond window, which serves as primary vacuum and tritium boundary of the ITER vacuum vessel and allows the transmission of high power mm-waves coming from the gyrotrons into the plasma. The window consists of an ultra-low loss CVD diamond disk mounted in a system of metallic parts and is integrated into the transmission line system. Because of its confinement function the window is classified as Protection Important Component (PIC) and high requirements for quality and safety apply. An ad-hoc qualification program is required for this specific component because it cannot be entirely covered by codes and standards.

Diamond disks with a diameter of about 70 mm and a thickness of 1.11 mm (resonance thickness for 170 GHz) will be used and need to be qualified with respect to their mm-wave transmission capability and mechanical stability. Qualification procedures are also to be established for the joining of the disk to the metallic structure, which is performed by brazing and finally for the qualification of the complete housing made of metallic parts, that are welded together.

The status of the window qualification program will be given together with results of already performed prototype tests.

KFM 8.2 Tue 9:50 PHY 5.0.20

Development of Diamond Windows Diagnostics for fusion applications — •Theo Scherer, Aurelian Tesniere, Gaetano Aiello, Francesco Mazzocchi, Andreas Meier, Sabine Schreck, and Dirk Strauss — Karlsruhe Institut für Technologie KIT, IAM-AWP, D-76344 Eggenstein-Leopoldshafen, Hermann-von-Helmholtz-Platz 1, Germany

The future nuclear fusion power plants will require Electron Cyclotron Heating and Current Drive (ECH&CD) systems to heat up and stabilize the plasma inside the vacuum vessel. One of the key components of such systems is the Chemical Vapor Deposition (CVD) diamond window. The purpose of this device is to act as vacuum and tritium boundary while providing a high microwave transparency with minimal reflectivity. Although suited for high power microwave operation, the windows shall be internally monitored in order to properly ensure the ECH system efficiency and safety. In this paper, the latest assessment study on a set of diagnostics to be part of the window assembly is shown. The required diagnostics include arc and tritium detection, microwave stray radiation (perpendicular to the main beam and generated by cracks in the windows), pressure and disk temperature measurements. To accommodate the diagnostics previously mentioned, a new design for the window housing was developed.

KFM 8.3 Tue 10:10 PHY 5.0.20

Brewster-angle diamond window for microwave application — •Gaetano Aiello[1], Theo Scherer[1], Thomas Franke[2], John Jelonnek[1], Andreas Meier[1], Dirk Strauss[1], Quang Tran[3], Christoph Wild[4], and Eckhard Woerner[4] — [1]KIT, Hermann-von-Helmholtz-Platz 1, Eggenstein-Leopoldshafen, Germany, 76344 — [2]EUROfusion Consortium, Boltzmannstrasse 2, Garching, Germany, 85748 — [3]Swiss Plasma Center (SPC), EPFL, Lausanne, Switzerland, 1015 — [4]Diamond Materials GmbH, Hans-Bunte-Strasse 19, Freiburg, Germany, 79108

The Brewster-angle diamond window is a broadband window solution for the frequency step-tunable gyrotrons in the context of the DEMO EC H&CD system. It consists of an elliptical CVD diamond disk brazed to two copper WGs at the Brewster angle of 67.2° for diamond. This window concept is being investigated for long pulse gyrotron operation at 2 MW power. Main challenges along this path are the production of very large area optical grade diamond disks suited for a 63.5 mm WG aperture, the proper joining of the disks to the WGs and the design of an effective cooling layout. A 63.5 mm WG requires a minimum disk diameter of 180 mm and 2 mm thickness. Available state of the art microwave plasma reactors are not able of growing diamond disks of such size. In collaboration with Diamond Materials GmbH, tests aiming to obtain large disks were thus investigated by different methods and experiments are still ongoing. In this work, the results of these experiments shall be reported, also together with the results of the FEM analyses aiming to investigate different window cooling layouts.

Break 20 min

KFM 8.4 Tue 10:50 PHY 5.0.20

ECRH system development for nuclear fusion reactors: Antenna design and diamond window implementation — •Dirk Strauss, Theo Scherer, Sabine Schreck, Peter Spaeh, Gaetano Aiello, Andreas Meier, and Francesco Mazzocchi — KIT Karlsruhe, Deutschland

The ITER ECRH system consists of 24 gyrotrons with up to 24 MW millimeter wave heating power at 170 GHz, power supplies, control system, transmission lines, one Equatorial and the four Upper Launchers. With its high frequency and small beam focus the ECRH has the unique capability of driving locally current. While the Equatorial Launcher mainly acts for central heating and current profile shaping, the Upper Launchers aim on suppressing MHD instabilities, especially neoclassical tearing modes triggering plasma disruptions. The Upper Launchers inject millimeter waves through a quasi-optical section. The eight overlapping beams have focal points optimized for suppression of NTMs. Changes in the design include new ex-vessel waveguide components with a reduced aperture and redesigned ultra low-loss CVD diamond windows.

Invited Talk KFM 8.5 Tue 11:10 PHY 5.0.20

Development of Kinetic Inductance Detectors for polarimetric applications in plasma diagnostics — •Francesco Mazzocchi[1], Eduard Driessen[2], Shibo Shu[2], Giovanni Grossetti[1], Dirk Strauss[1], and Theo Scherer[1] — [1]Karlsruhe Institute of Technology, Eggenstein Loepoldshafen, Germany — [2]Institute de RadioAstronomie Millimetrique, Grenoble, France

Polarimetry is a technique that measures the Faraday rotation in a magnetized medium, such as a fusion plasma. It allows to determine various fundamental plasma parameters, such as current density when used independently from other diagnostics and like poloidal field and electron density when coupled to specific systems (i.e. interferometry). To mitigate these issues of current systems, we have considered to use in our device a Quantum Cascade Laser (QCL). The lack of power of such source requires the use of extremely sensitive detectors, hence the development of custom superconducting Kinetic Inductance Detector (KID) presented in this work. The whole system will be composed of a cryostat containing the source and the detector (both of which require cryogenic temperatures to operate optimally) and a beam delivery system, consisting of suitable waveguides and a diamond window on the reactor side, to have a very strong pressure barrier between the tritium rich atmosphere of the fusion reactor and the vacuum of the polarimeter side waveguides. The dielectric and mechanical properties of the synthetic diamond allow us to have such barrier without compromising the beam transmission factor.

KFM 8.6 Tue 11:40 PHY 5.0.20

Diamant und die Knickpyramide in Ägypten: Eine überraschende Gemeinsamkeit — •Peter-Michael Wilde — 15711 Königs Wusterhausen, Deutschland

Der Habitus und die Zusammensetzung von kristallinen Mikroobjekten auf Silicium (111)- Substraten wurden mit SEM und EDX aufgeklärt. Mittels des LPE Verfahrens waren Felder von Mikropyramiden erzeugt worden, deren Böschungswinkel typisch sind für die kubische Struktur von Diamant. Mikroanalysen ergaben die Zusammensetzung C - Si - Ge, wobei die Verhältnisse dieser drei Elemente bei konstantem Böschungswinkel gezielt variiert werden können. Die aus Kalkstein errichtete Kickpyramide von Dahschur mit über 105 m Höhe weist fast bis zur Hälfte den gleichen Böschungswinkel von 54,5 Grad auf, wie er für die Diamantstruktur typisch ist. Über die geometrische Tangens-Funktion ergibt sich ein Zahlenwert von 1,41 in sehr guter Übereinstimmung mit dem Wert Quadratwurzel aus 2. Auch bei der Realisierung des oberen Teils der Knickpyramide kommt eine Wurzelfunktion von 2 zum Tragen. Das sind überraschende Befunde, da die Mathematik der alten Ägypter die Operation des Radizierens nicht kannte. Es wird eine Erklärung hierzu vorgestellt.