O-06 **Session A, Tuesday, 14.06., 12^{20} - 12^{40}**

Development and characterization of a compact laboratory laser-plasma soft X-ray source and its usage for contact microscopy

M. G. Ayele[1]*, P.W. Wachulak[1], J. Czwartos[1], D. Adjei[1], A. Bartnik[1], Ł. Wegrzynski[1], M. Szczurek[1], L. Pina[2] and H. Fiedorowicz[1]

[1]*Institute of Optoelectronics, Military University of Technology, Kaliskiego 2 Str., 00-908 Warsaw, Poland*
[2]*Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Brehova 7, CZ-115 19 Prague 1, Czech Republic*

Keywords: laser-plasma, soft X-rays, gas-puff target, water window X-ray microscopy

*e-mail: mesfin.ayele@wat.edu.pl

Applications related to soft X-ray microscopy is quite attractive, because soft X-ray radiation can achieve good contrast images of unstained, wet, and several micrometers thick specimens in the 'water window' [1-2]. The 'water window' is a range of soft X-ray energy between K-absorption edges of oxygen (540 eV) and carbon (284 eV),. Within the 'water window' spectral range, water is relatively transparent, while carbon, nitrogen, and other elements found in the structure of biological specimens are still absorbing. For this reason, soft X-rays in the 'water window' spectral range can be utilized for living specimen study without chemical fixation or dehydration that is required in electron microscopy. Furthermore, the shorter wavelength of the X-ray radiation, relative to visible light, allows for better resolution imaging beyond the limits of optical microscopy.

Several sources including, synchrotrons and free electron lasers for generating 'water window' soft X-rays were developed. These devices are the state of art designed for cutting-edge experiments; however, limited access and high cost to such sources encourages the development of a laboratory based soft X-ray sources, which could provide a complementary platform to the large scale facilities. A number of laboratory laser-plasma soft X-ray source were developed for microscopy applications [3-5]. A solid target is conventionally used in such sources; however, debris production due to laser ablation is the main challenge. To eliminate this problem, the use of a gas-puff target instead of a solid target was proposed [6-7].

In this work, we present a laboratory laser-plasma source of soft X-rays, developed and characterized for contact microscopy application. The source is based on a double-stream gas puff target, irradiated with a commercially available Nd:YAG laser (from EKSPLA), delivering energy up to 740 Mj, with 4 ns pulse duration, and 10 Hz repetition rate. The target is formed by pulsed injection of working gas (argon) into a hollow stream of helium gas using a double nozzle electromagnetic valve [8]. The source is designed to produce nanosecond pulses of soft X-rays in the 'water window' spectral range, to enable the irradiation of samples both in vacuum and in helium atmosphere. The source delivers fluence of about 3.70 x 103 photon/μm2/pulse at a sample placed in air at a distance of 21 mm, downstream of the source. It also delivers a photon fluence of about 1.90 x 102 photon/μm2/pulse for a sample placed in helium atmosphere at the same position. The construction of the source, and results of the characterization measurements, as well as preliminary contact microscopy experiments are presented and discussed.

Acknowledgments: This Work is supported by the Education, Audiovisual and Culture Executive Agency (EACEA) Erasmus Mundus Joint Doctorate Programme Project No. 2012 – 0033. We also acknowledge the support from 7th Framework Programme Laserlab Europe project (No. 654148). This work is also supported by the National Centre for Science; award number DEC 2011/03/D/ST2/00296, the National Centre for Research and Development, Lider programme, award #LIDER/004/410/L4/12/NCBR/2013. We also acknowledge our collaborators, the Institute of Electronic Materials Technology (ITME, Poland) and the Institute of Nuclear Physics, Polish Academy of Sciences Kraków, Poland for the material support.

[1] J. Kirz, D. Sayre, *Synchrotron Radiat. Res* (1980) 277.
[2] T. W. Ford, A. D. Stead, R. A. Cotton, *Electron Microsc Res* **4** (1991) 269.
[3] P. Albertano, L. Reale, L. Palladino, A. Reale, R. Cotton, S. Bollanti, K. Vigli Papadaki, *J Microsc* **187** (1997) 96.
[4] T. Majima, *Trends Anal. Chem* **23** (2004) 520.
[5] M. Kado, H. Daido, Y. Yamamoto, K. Shinohara, M. C. Richardson. *Laser Phys Lett* **3** (2005) 205.
[6] H. Fiedorowicz, A. Bartnik, Z. Patron, P. Parys, *Appl. Phys. Lett.* **62** (1993) 2778.
[7] H. Fiedorowicz, A. Bartnik, J. Kostecki, M. Szczurek, SPIE **2723** (1996) 310.
[8] A. Bartnik, H. Fiedorowicz, R. Rakowski, M. Szczurek, F. Bijkerk, R. Bruijn, H. Fledderus, *Proc. SPIE* **4424** (2001) 406.