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What Happened to Marton's Dream of a Field Emission X-ray Microscope?

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INTRODUCTION

In 1951 at a symposium on Electron Physics, L. Marton gave a very enthusiastic appeal for the development of a Shadow Projection x-Ray Microscope employing a field emission electron source. At that time he was envisioning exposure times so short as to permit full speed x-ray microscopic movies in a resolution beyond the optical microscope. Two and one half years later, when the proceedings finally appeared, Marton was less optimistic (Electron Physics 1954). His written paper addressed the many problems and his predictions were considerably lowered. However, he never lost hope that the much higher brightness of the field emitter would eventually be made available for x-Ray Microscopy. Marton passed away about ten years ago without his dream being realized.

Today, despite the many improvements in field emission, few workers are looking to it for x-ray microscopy. The purpose of this paper is to examine its possible role for x-ray microscopy.

THE FAMILY OF X-RAY MICROSCOPES

Already we see a proliferation of models of the x-Ray Microscope and can expect more with maturity of our field. In attempting to classify and compare the known possible approaches to x-ray microscopy, we find the source of x-ray illumination to be the most distinguishing feature. The following sources have been used: thermionic electron impingement, Synchrotron radiation, variously excited plasma, and true x-ray lasers.

The opportunity to use field emission would most likely be as a replacement for thermionic electron sources in direct production of x-rays. The joint abilities to pulse field emission and to employ multiple sources in parallel may provide high total currents which could possibly make field emission useful in plasma generation. Electron impingement and plasma have a very important advantage for work with higher energy x-rays over the powerful synchrotron based microscopes, in that they can be used in an ordinary laboratory space at much less cost. Their disadvantage lies in their low intensity in the water window and their lack of a general monochromator for chemical identification. Some possible ways to overcome these disadvantages are discussed by the author in another paper at this conference, i.e. "Can x-ray photometry be applied to 3-D Images?".

SCOPE OF THIS PAPER

In this paper we shall limit our discussion to ways in which field emission might produce a smaller, more productive, direct electron impact, type microscope based on the classical Shadow Projection principle. This choice does not imply that larger direct impact type microscopes based on a scanning electron microscope structure with ultra thin targets have no place in the family of x-Ray Microscopes, but rather that field emission is less attractive than the more robust lanthanum hexaboride cathodes for these instruments.

The approach which I favor, should employ the recently developed atomic sized tip which Scheinfein et al have shown to indeed have two orders of magnitude more brightness than the larger tip sources (Scheinfein et al. 1993) and Spence et al have applied to electron shadow imaging (Spence et al. 1993). These tips require very low extraction voltages and thus can be made immune to ion destruction even in a 10^{-6} Torr surrounding. Because of their small physical size it is possible to consider a table top configuration. Furthermore a sealed envelope with built in holding pump is practical in the 10 kV range (Newberry 1993) which eliminates a bulky and expensive demountable pumping system. A suggested layout for such a system will be discussed. It will be appropriate for opaque samples in the thickness range of confocal microscopy. Sealed sources for more penetrating radiation would be better served by dispenser cathodes. Thus at least two versions of the sealed Shadow Projection x-Ray Microscope can be expected along with the SEM demountable vacuum version.

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REFERENCES

"Electron Physics", National Bureau of Standards Circular 527, issued March 17, 1954, (Proceedings of the Semicentennial Symposium on Electron Physics, held at the NBS on Nov.5-7, 1951, Bureau of Standards, L. Marton Chairman).

Scheinfein MR, W Qian, JCH Spence. 1993. "Brightness Measurements of Nanometer-sized Field-Emission Tips", MSA Proceedings 1993 p 632-3.

Spence JCH, W Qian, J Liu, W Lo. 1993. "Experimental low-voltage point projection microscopy", MAS Proceedings p 1060-1.

Newberry S.P, 1993. "Is a aealed ahadow projection x-ray microscope possible?". To be published in Proceedings of XRM'93, Moscow.