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Rapid Communication

First Image from a Positron Reemission Microscope

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We report in this note that we have taken the first images (one of which is shown below) using a Positron Reemission Microscope (PRM) i.e., a microscope based on the imaging of positrons (e^+) reemitted with a few eV energy from a target. Some of the contrasts which appear in the PRM are totally different from the recently demonstrated Transmission Positron Microscope[1] and also from those present in any version of an electron microscope. See reference 1 for a discussion of, and references to, positron microscopy.

A primary slow e^+ beam of 5×10^5 e^+/sec is generated by the now standard process of moderating high energy ($\sim 10^5$ eV) e^+ from a 35 mCi ^{22}Na radioactive source down to an energy of ~ 1 eV using a set of annealed tungsten strips.[1] The primary beam is focused onto a target at an energy of 2 keV. Reference 1 provides a detailed description of all essential details of the primary beam. The incident beam loses energy in the target by a variety of processes until the e^+ reach near thermal energies. These thermalized e^+ diffuse to the incident surface where up to 40% are reemitted with a kinetic energy of a few eV. The reemitted e^+ are accelerated and focused by an electric field, and then focused by an objective lens and a projector lens, onto a channel electron multiplier array (CEMA). The CEMA allows the formation of an image, after suitable signal averaging techniques, at current densities as low as 10^{-18} A/cm^2, as described in detail in Ref. 1.

The image shown is a copper grid (dark lines, low e^+ reemission) resting on an annealed polycrystalline W foil substrate (bright squares, high e^+ reemission). The image was taken after adjusting the objective lens voltage until the grid was in focus. The image was acquired in four hours. The magnification of $M = 28\times$ is calibrated from the known 250 μm grid wire spacing and the resolution of R $= 4.5 \pm 0.6$ μm is measured from a gaussian fit to a histogram of one of the grid wires. Both M and R agree with our theoretical estimates.

We are now pursuing several applications of the PRM, including defect imaging of metals and the imaging of semiconductors and biological specimens, which will be discussed in subsequent publications as results become available. Straightforward improvements in the current (prototype) PRM to R$\simeq 0.5$ μm are underway. We also plan to construct an entirely new instrument with R projected to be 10^{-2} μm in the near future.

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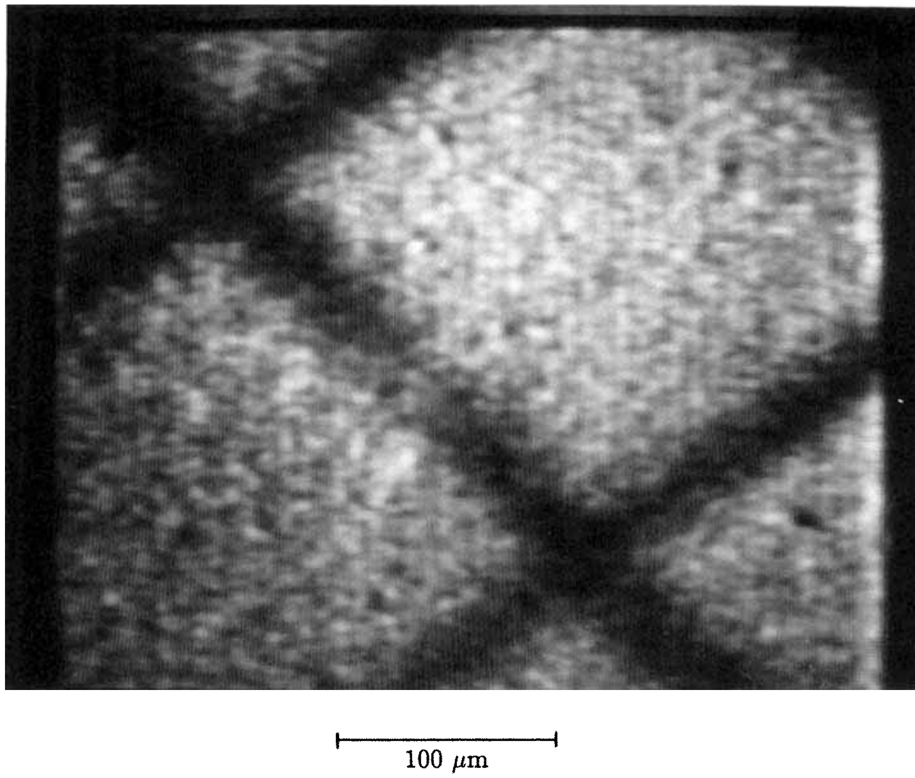

Fig. 1 A PRM image taken under conditions discussed in the text. It shows a Cu grid (low e^+ reemission) on a W substrate (high e^+ reemission) taken at M= 28×.

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References

[1]Van House, J., and Rich, A. (1988) First Results of a Positron Microscope. Phys. Rev. Lett., 60:169-172.