Design study of linear accelerator-based positron re-emission microscopy

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The positron re-emission microscope (PRM) [1,2] images positrons that are re-emitted from surface after thermalization and diffusion of positrons implanted into material. By using PRM, it is able to nondestructively observe spatial distribution of vacancy-type defects at atomic levels below the detection limits of electron microscopy. Compared with scanning positron microscopy, PRM potentially has better lateral resolution with faster imaging time by more than one order of magnitude. However, in the previous studies of PRM [1-3], a long imaging time (more than 8 hours) was needed to acquire one image because radioisotope (RI) was used as a positron source. For practical use, a substantial reduction of the imaging time is required.

In order to solve this technical problem, we are developing PRM with an intense positron beam produced by using an electron linear accelerator (LINAC). Positron beam intensity with the LINAC can be more than one order of magnitude higher than that with the RI source, and improvement of signal-to-noise ratio of the PRM imaging is expected by synchronizing image acquisition with the LINAC pulsed beam (Δt ~ 1 μsec). An optical column of photoelectron emission microscopy (PEEM) was used for the PRM. The re-emitted positron image is magnified by three sets of electrostatic lenses, amplified by a micro channel plate (MCP), and projected onto a phosphor screen. The focused image on the screen is recorded by a CCD camera. In this presentation, we will report on the positron trajectory calculation for the PRM as well as the current status of our PRM equipment under construction.