

Biomedical applications of MeV ion microbeams

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Nuclear microscopy is a generic term referring to a large panel of ion beam analysis techniques carried out using light ion microbeams in the MeV energy range (typically H^+ , D^+ and He^+ , from 1 up to 4 MeV). After twenty years' experience by world-wide research groups in the use of those microbeams (the first dedicated conference was held in Oxford in 1987), nuclear microscopy is now recognised as a powerful technique for routine chemical microanalysis and elemental mapping in the frame of biomedical applications.

The lateral resolution achieved by advanced facilities is about 50 nm in low flux mode for pure imaging techniques and 300 nm in high flux mode for trace elements analysis and mapping. Since MeV ions may induce both nuclear and atomic excitation, a non-exhaustive list of available methods includes PIXE (Particle Induced X-ray Emission), NRA (Nuclear Reaction Analysis), RBS (Rutherford Backscattering Spectrometry), STIM (Scanning Transmission Ion Microscopy). PIXE is the basic method employed for routine elemental mapping. Numerous applications in biomedicine take advantage of its versatility and easy operation, either at the tissue or individual cell scale.

During the last decade, an efficient new methodology appeared for targeting individual cells with light or heavy ions that overcame the statistical uncertainty on cell traversal number inevitably associated with broad beam irradiation. In the frame of radiation biology studies, it helped to reduce significantly cell to cell dose fluctuations together with the associated threshold effects on cellular response.

The CENBG microbeam was commissioned in 1989 at the old Van de Graaff accelerator. This beamline was recently transferred on the new AIFIRA facility and a nanobeam is going to be commissioned end of 2007. The first line was initially designed for easy and reliable micro-PIXE analysis of biological samples and biomedicine has been the main research area developed on this system. This microbeam has been also extensively used during the last five years to develop a research programme on cellular response to alpha particle targeted irradiation. In this review, different examples of investigation will be presented with emphasis placed on dermatology, pathology, pharmacology and radiation biology.