The properties of X-rays that give them their special role in microscopy are short wavelengths which allows high spatial resolution, high penetrating power and a near absence of impedance mismatch at interfaces which is especially important for imaging of thick hydrated specimens. X-ray energies suited for microscopy provide natural contrast mechanism as well as chemical bond mapping using K-shell and L-shell resonances of many elements in the periodic chart. Therefore, in recent years there have been considerable developments of X-ray microscopes and scanning X-ray microscopes in several countries, using third generation synchrotron radiation sources and zone plate optics as high-resolution X-ray lenses. Besides systems working with X-rays at energies between the carbon and oxygen K edges at 284 eV and 534 eV respectively - the so-called water window - systems have been developed for harder X-rays in the keV-region. X-ray microscopy is currently being used for investigations in biology, medical research, colloid physics, environmental sciences as well as in material research, for example to study domain structures in magnetic materials. For biological applications and especially for X-ray microscopic topographic imaging to reveal 3D-structures cryo-X-ray microscopy is of importance.

Keywords: X RAY MICROSCOPY, X RAY MICROSCOPE, X RAY OPTICS

Ongoing competitive development of diffraction and computational techniques has resulted in the determination of electron density in the intermolecular space of the crystals with a typical uncertainty of 0.03-0.08 eÅ⁻¹. Corresponding structural models portray a crystal as a ‘sea’ of electron density with immersed nuclei. This picture is close to the quantum mechanical description, however, it takes away from canons, which consider a crystal (and molecule) as a set of atoms linked by a network of chemical bonds. Therefore, great efforts were made to establish which atoms, in terms of electron density, are directly bonded and which are not. Additionally, numerous attempts to quantify the atomic and molecular interactions were undertaken. As a result, a language used to interpret the electron density pictures now re-presents the sophisticated and often contradicting mixture of classical and quantum concepts. Certain progress in removing the contradictions has taken place in the last few years. In particular, topological analysis of the electron density was expanded to include the electro-static potential, local energy characteristics and electron localization function. There is a question whether these developments provide new insights on the nature of atomic and molecular interactions. In search of an answer to this question we shall consider the most recent results dealing with electron density features in compounds with different types of chemical bonds. We shall also consider a structural model of electron density in comparison to one, which is geometrical and outline some perspectives of approach such as quantum crystallography and biological applications.

Keywords: CHARGE DENSITY TOPOLOGY