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Resonance Coherent Diffraction Imaging: new opportunities for free electron laser science

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The high transverse coherence and peak brightness of ultra-short SASE-FEL pulses have already demonstrated the extraordinary potential for coherent diffraction imaging (CDI) in a single shot experiment before the radiation damage of the sample is manifested [1]. The limitations imposed by the partial longitudinal coherence of SASE-FEL for getting selective chemical information using single shot resonant (R-) CDI, should be overcome by the *seeded* FEL sources. This opens unique opportunities for single-shot R-CDI experiments with access to elemental and/or magnetic structure of morphologically complex targets using the energy tunability and multiple (circular or linear) polarization of the fully coherent seeded FEL pulses. The ultimate lateral and temporal resolution are determined by the wavelength and pulse duration of such photon sources and these parameters are considered for experiments to be performed at the soft x-ray seeded FEL facility with beam wavelengths starting from 3-4 nm in the first harmonics.

Among the most appealing applications using short and intense fully coherent pulses are studies of dynamic systems. The soft x-rays are excellent for monitoring temporal evolution of the conformation states of living cells [2]. In this respect understanding the cellular responses to agents that have penetrated different cell organelles is a long-term challenge and an important relevant information is encoded in the speckle patterns. Another hot topic is exploring anisotropic nanostructures, fabricated by different elements, under "extreme conditions" [3]. Using as a pump an optical laser or a split in time FEL pulse the set of speckles taken at different delay times for wavelengths matching different atomic edges will reveal selectively how each sub-structure evolves. R-CDI using multiple polarization of the pulses enhances the magnetization scattering and allows tracking the temporal response of magnetization density and domain dynamics in nano-structures triggered with an optical laser pump, crucial for deeper understanding and developing new magnetic materials.

The DiProI beamline, including split-delay correlation system and focusing KB optics for demagnifying the beam to a 3x5 μm^2, and the end station at free electron laser facility FERMI@ELETTRA are designed to meet the requirements for performing a wide range of static and dynamic The presentation will include results from CDI and R-CDI experiments with synchrotron radiation source, obtained with the end station [4] and the first commissioning tests with seeded pulses at FERMI@ELETTRA.

1) H. N. Chapman et al, *Nature Physics* 2, 839 (2006).
2) M. M. Seibert et al, *Journal of Physics B:* 43, 194015 (2010).
3) B. Nagler et al, *Nature Physics* 5, 693 (2009).
4) E. Pedersoli, F. Capotondi et al, Rev. Sci. Instrum. 82, 043711 (2011).