Adaptive Diffraction grating for a compensated high order harmonics monochromator

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High-order laser harmonics (HHs) that are produced by the interaction between a very intense ultrashort pulsed laser and a gas jet, are widely used as radiation sourcesin the extreme ultraviolet (XUV) and soft X-ray regions with high degree of coherence, high brightness and peak intensity and ultrashort duration. The HH spectrum is described as a sequence of peaks corresponding to the odd harmonics of the fundamental laser wavelength. The use of the XUV emission in a narrow band requires the spectral selection of a single harmonic with a suitable low-resolution monochromator that has to preserve the pulse temporal duration of the XUV pulse as short as in the generation process.

Broad-band tuneable monochromators in the XUV are usually realized by reflection gratings at grazing incidence. Unfortunately, a grating gives inevitably a distortion of the temporal profile of the ultrashort pulse because of diffraction. At first order, each ray that is diffracted by two adjacent grooves is delayed by the wavelength λ. The total difference in the optical paths of the diffracted beam from the source to the image is given by λN, where N is the number of the illuminated groves. For example, let us consider a 200 gr/mm grating illuminated by radiation at 30 nm over a surface of 20 mm. The number of grooves that is involved in diffraction is 4000, giving a total delay of 120 μm, i.e. 400 fs. This effect is negligible in the picosecond or longer time scale, but it is dramatic in the case of a femtosecond pulse. Nevertheless, it is possible to design grating monochromators that do not alter the temporal duration of an ultrafast pulse by using at least two gratings in subtractive configuration to compensate for the dispersion. Grazing-incidence compensated monochromators have recently been realized based on two symmetric sections, each of them consisting on a collimating mirror, a plane grating and a focusing mirror [1, 2]. This design has been proved to be very effective, but it is quite complex since it mounts six optical elements.

We present a new design of a XUV time-compensated monochromator for ultrafast pulses based on adaptive diffraction gratings which will have the following advantages:

1. It has just two optical components, namely the two gratings
2. It is easy to be aligned
3. It has the maximum efficiency for a given grating geometry
4. It is fully tunable in a broad spectral range keeping fixed the source point and the output point.

The layout of the monochromator is illustrated in Fig. 1:

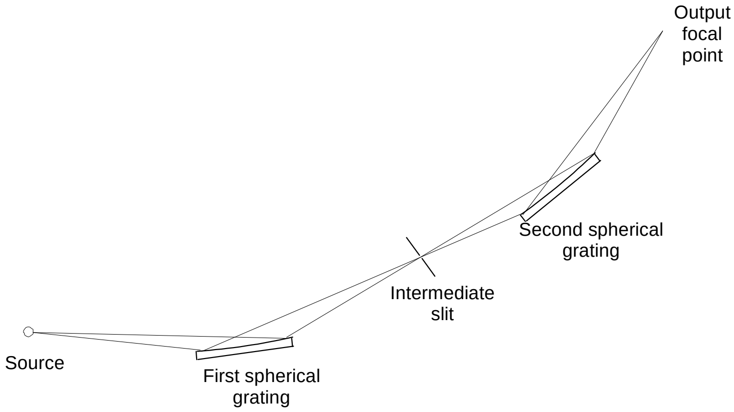

Fig.1: optical design of adaptive compensated monochromator.

As a first step in the development of the XUV monochromator, we have developed a time-compensated model in the visible. In this device the diffraction gratings, with groove density of 50lines/mm, are mounted on a bimorph deformable mirrors. The minimum radius of curvature is about 1.5m (Fig. 2-3).

The diffraction grating is realized by coating a bimorph deformable mirror with a photosensitive hybrid organic-inorganic film, with a thickness of 0.9µm. UV mask lithography was used to produce lines 25 µm wide after exposure and development.

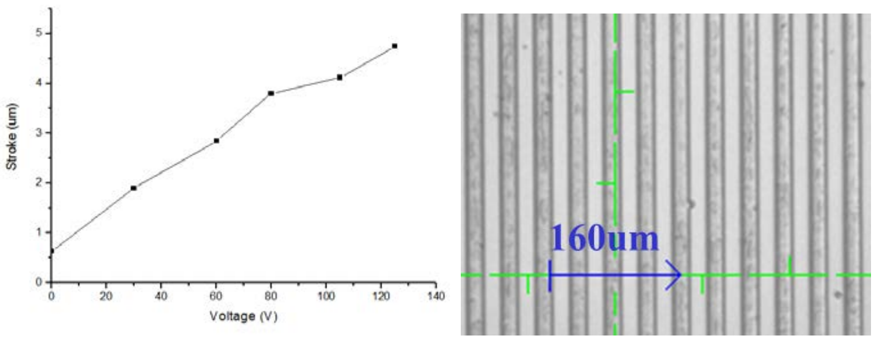

Fig. 2a: Peak to Valley deformation of the deformable diffraction grating as defocus corrector.2b) rulings of the adaptive diffraction grating.

References

1. L. Poletto, P. Villoresi, E. Benedetti, F. Ferrari, S. Stagira, G. Sansone, M. Nisoli, Intense femtosecond extreme ultraviolet pulses by using a time-delay compensated monochromator, Opt. Lett. 32, 2897-2899 (2007)

2. L. Poletto, P. Villoresi, F. Frassetto, F. Calegari, F. Ferrari, M. Lucchini, G. Sansone, M. Nisoli, Time-delay compensated monochromator for the spectral selection of extreme-ultraviolet high-order laser harmonics, Rev. Sci. Inst. 80, 123109 (2009)