# A New Generation of Soft X-Ray Lasers

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A survey of the X-ray laser (XRL) schemes used in practice and the newest development trends of laser-plasma-based X-ray lasers are given on the background of the historical development in the field. It starts with the demonstration and explanation of the transient inversion scheme that reduced the pump energy needs by two orders of magnitude and promoted the plasma XRLs to the group of table-top devices. Demonstration of the Grazing Incidence Pumping (determined as GRIP), being a variant of the transient inversion scheme, opened for XRLs the door to the class of high-repetition rate sources. The pump energy has been reduced to less than 1 J and commercial pump lasers could be applied as the drivers. All this progress has been achieved by reducing of the active medium volume, i.e. the volume of the efficiently pumped plasma. This caused the total scheme efficiency to be unchanged and kept at a level about $10^{-6}$. Such lasers showed an outstanding longitudinal/temporal coherence of 1-2 ps. However, usually only few percent of the total number of photons in an XRL beam are coherent, indicating a limited spatial coherence. At the present state of the source development it is the right time to convert the XRL from a pure laboratory tool into a stably operating instrument suitable for many applications.

The newest development, based on seeding an amplifying medium with high harmonics (HH) starts to be pursued vigorously. Some unprecedented qualitative changes, such as XRL with sub-picosecond output pulses, well defined polarisation and nearly full coherence are expected. A fascinating physics being behind this XRL scheme will be discussed in detail. There is a significant mismatch between the typical bandwidths of XRL and high harmonics. It means the seeding signal is at least one order of magnitude spectrally broader than the amplifying medium. This can cause two absolutely different regimes of the amplification. The control over the amplification regime decides about the energy extraction efficiency. Short-lived, very high swept-gain makes the process more complex. In spite of this, seeding is a very promising method for achieving a new quality in the output parameters through shortening the pulse and control over the polarisation and coherence of the XRL beam.

The progress in the development of the schemes sketched above will depend on the development in the technology of driving lasers. Also here new trends are observed. A clear tendency to go with the working wavelength towards the "water window" by using reasonably strong lasers (E<100J) is present. On the other hand high repetition rate systems seem to be more flexible, even if only in the XUV spectral range (10-20 nm). MBI has chosen the latter way and a new laser driver suitable to pump the medium in the GRIP geometry at a repetition rate of 100 Hz is being constructed. The CPA(chirped-pulse-amplification)-system consists of a Yb:KGW-diode pumped oscillator and regenerative amplifier. The pulse from the oscillator is stretched for more efficient energy extraction. The next regenerative amplifier (Yb:YAG) completes the system´s front-end. The following

amplifying modules built in the thin disk technology (Yb:YAG ) should deliver after compression two pulses with the parameters needed for efficient pumpung of XRLs.
The competitive and complementary sources – especially those emitting keV photons – continuously strengthen their presence in consciousness of potential users and the position of the X-ray lasers in this aspect will be discussed concisely.