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Nota di contenuto	Introduction -- Theoretical Background -- Design of High-Power Enhancement Cavities -- Megawatt-Level Average Power Enhancement Cavities for Ultrashort Pulses -- High-Harmonic Generation at 250 MHz Repetition Rate -- Summary & Outlook.
Sommario/riassunto	This thesis discusses the power scaling of ultrashort pulses in enhancement cavities, utilized in particular for frequency conversion processes, such as Thomson scattering and high-harmonic generation. Using custom optics for ultrashort-pulse enhancement cavities, it demonstrates for the first time that at the envisaged power levels, the mitigation of thermal effects becomes indispensable even in cavities comprising solely reflective optics. It also studies cavities with large beams, albeit with low misalignment sensitivity, as a way to circumvent intensity-induced mirror damage. Average powers of several hundred kilowatts are demonstrated, which benefit hard x-ray sources based on

Thomson scattering. Furthermore, pulses as short as 30 fs were obtained at more than 10 kW of average power and employed for high-harmonic generation with photon energies exceeding 100 eV at 250 MHz repetition rate, paving the way for frequency comb spectroscopy in this spectral region.