# Foreword 1

2015 is the year that the United Nations has declared as the *International Year of Light*. Light-based technologies change our economies and lifestyles. They become vital in our daily lives. Also the winners of the latest Nobel Prizes focus on photonics.

The Nobel Prize for physics had been awarded to Isamu Akasaki, Hiroshi Amano and Shuji Nakamura who developed the blue LED. Stefan Hell, Eric Betzig and William Moerner won the Nobel Prize for chemistry for super-resolved fluorescence microscopy with a resolution far beyond Abbe's diffraction limit of about half the wavelength (200 nanometers). Pushing optical microscopy into the nanodimension with certain fluorescent molecules, microscopy "turned" into *nanoscopy*. A resolution below 10 nm has been achieved in fluorescence nanoscopy using visible light.

But microscopes and nanoscopes are not just analytical tools. They can also operate as highly precise nanomaching tools with features sizes below 100 nanometers even when operating in the near infrared (NIR). Non-linear optics, in particular multiphoton effects, made that possible.

The PhD student and later Nobel Prize Winner Maria Göppert predicted multiphoton effects in the late twenties of the last century. It took about 30 years until the first laser was built to prove her hypothesis by the generation of second harmonic generation (SHG) and two-photon fluorescence in 1961. Again 30 years later the first two-photon laser microscope was built utilizing a femtosecond dye laser. One decade later, multiphoton tomographs became medical devices and the first stimulated emission depletion (STED) microscope was realized. Both systems were based on titanium:sapphire femtosecond laser technology.

With the new millennium, femtosecond NIR laser systems became novel micromachining tools in material production and in refractive eye surgery.

And within the last 10 years, femtosecond NIR laser technology "turned" micromachining into nanomachining. These novel nonlinear photonic nanoprocessing tools are based on two-photon and STED-lithography as well as on multiphoton ionization and plasma formation. In-bulk nanoprocessing became feasible when using non-ultraviolet (UV) laser radiation.

This book refers to the latest developments in laser-produced sub-100 nanometer features, typically with femtosecond NIR laser systems. 15 research groups consisting of engineers and natural scientists describe the basics of femtosecond laser – material interaction and the interior of the novel nanotools. Technical and biomedical applications such as STED-lithography to develop protein nanoanchors, production of ultrathin resists, biochemical sensors and scaffolds, laser-induced periodic nanostructures for friction control in titanium and steel as well as virus-free optical reprogramming of cells are demonstrated.

The editors and authors of this book wish to thank the *German Science Foundation* for the possibility to publish their latest results within this open access book and for long-term funding within the Key Project SPP 1327 (2008–2015).

May 2015

Karsten König
Biophotonics and Laser Technology
Saarland University
Germany

Andreas Ostendorf
Applied Laser Technology
Ruhr University Bochum
Germany