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LECTURE

“Advanced techniques in nonlinear optics and imaging for biomedical and industrial applications”

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Advanced techniques in nonlinear optics and imaging for biomedical and industrial applications

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This presentation introduces nonlinear optics and imaging techniques for their impact on both biomedical and industrial domains. Exploration of optical processes such as nanoparticle plasmon absorption, material breakdown, optical switching, and high-resolution microscopy, underscores the versatility of laser-matter interactions. Specifically, laser ablation is employed in this research to fabricate metallic nanoparticles and nano-alloys. Fine-tuning the plasmon resonance of metallic nanoparticles, thereby influencing their linear and nonlinear optical properties, holds immense promise for advancing highly sensitive biosensors and therapeutic agents among other applications. Moreover, employing laser ablation with ultrashort pulses induces highly localized damage, presenting a promising path for reducing patient recovery time post-surgical procedures.

In addition, advanced methodologies such as wavefront shaping and deep learning is demonstrated in the context of fiber endoscopy. Utilizing thin fiber probes facilitates the transmission of information from inaccessible areas within the human body, unattainable by conventional microscopes. The pursuit of more compact endoscopic devices propels the investigation of various fiber types for their potential to integrate superior imaging modalities and microsurgery capabilities while maintaining an ultrathin profile (less than 400 µm). The application of wavefront shaping has enabled the integration of femtosecond laser ablation and two-photon fluorescence imaging within the same multimode fiber. A groundbreaking demonstration of selective tissue modification at a cellular level has been achieved using two-photon fluorescence as a guide. Furthermore, deep neural networks exhibit remarkable potential for information recovery in complex systems. The use of intensity-only images from speckle patterns emerging from multimode fibers allows for the prediction of input images. Notably, deep learning for multimode fiber imaging demonstrates resilience to perturbations related to mechanical, thermal, and wavelength drifts. Both methodologies underscore the value of optical fibers in biomedical imaging and information retrieval.

Lastly, examining the presented technologies from an industrialization standpoint sheds light on the intricacies of photonics product development and the vital link between research, industry, and end-users.