

LIGHTSABERS (“LASTER SWORDS”) FOR IMPROVING PHOTODETECTOR SPEED AND RESPONSIVITY

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The micrometer scale of optics is significantly larger than the nanometer scale of modern electronic devices. To produce photodiodes yielding both superior speed and responsivity, a critical challenge is to confine the incident light efficiently to an active region having a small (subwavelength) area. In recent years, plasmonics has been applied as a means to confine light to subwavelength areas. In this case, the plasmonic structure converts the incident (far-field) light into near fields in order to achieve the sub-wavelength confinement. However, the surface plasmons are a near-field phenomenon such that the electromagnetic energy does not penetrate deeply. Further, surface plasmon resonances are generated only over narrow range of frequencies. Thus, the question arises: can we avoid the conversion to near fields and propagate the light into the semiconductor over a sub-wavelength area? When desired, can we propagate broadband electromagnetic energy into the sub-wavelength area to provide efficient broadband photodiodes? The latter may especially be desirable if the common silicon semiconductor is replaced with a more broadband semiconductor such as graphene. Here, it is proposed that a propagating sub-wavelength beam of light called a photonic nanojet and resembling a lightsaber or “laser sword” can be used to focus light onto the small active area of a photodiode. Exploratory three-dimensional, Maxwell’s equations finite-difference time-domain (FDTD) simulations are conducted and demonstrate that the nanojets can confine light to an area comparable to a nanostructured dipole antenna while propagating multiple wavelengths into the semiconductor, even over a broad range of frequencies when desirable.