implant of the reset MOSFET through the conventional n well. The reset and source-follower MOSFETs would reside in the p well as in the conventional device structure.

Unlike in the conventional device structure, the deep n well would electrostatically separate the p well in the vertical direction from the p epitaxial layer or substrate. The horizontal isolation of photodiodes in adjacent pixels from each other would be achieved by the deep p wells: Each deep p well would establish a potential barrier that would prevent electrons in the deep n wells of adjacent pixels from communicating with each other.

Inasmuch as the conventional and deep p wells would both be electrostatically isolated from the p epitaxial layer or substrate by the deep n well, any reverse (negative) bias could be applied to the p epitaxial layer or substrate without causing the potential difference between the n and p wells to increase beyond the typical conventional range of 2 to 3 V. Depending upon the resistivity of the substrate, a back-side reverse bias in excess of 50 V could be applied to achieve depletion widths as large as 50 μm, while the MOSFETs could be operated with conventional CMOS power supplies and biases. Thus, the incorporation of the deep n well and p well would allow the integration of a photodiode with a very large back-bias and very large depletion width alongside state-of-the-art MOSFETs with small supply voltages, resulting in the development of high-performance CMOS imager sensors.

This work was done by Bedabrata Pain of Caltech for NASA's Jet Propulsion Laboratory.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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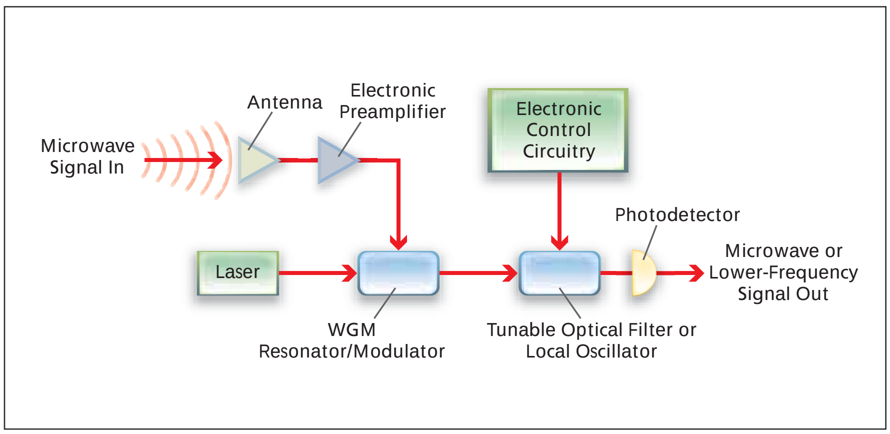
Wide-Band Microwave Receivers Using Photonic Processing

One receiver would have the functionality of multiple traditional heterodyne microwave receivers.

NASA's Jet Propulsion Laboratory, Pasadena, California

In wide-band microwave receivers of a type now undergoing development, the incoming microwave signals are electronically preamplified, then frequency-up-converted to optical signals that are processed photonically before being detected. This approach differs from the traditional approach, in which incoming microwave signals are processed by purely electronic means. As used here, "wide-band microwave receivers" refers especially to receivers capable of reception at any frequency throughout the range from about 90 to about 300 GHz. The advantage expected to be gained by following the up-conversion-and-photonic-processing approach is the ability to overcome the limitations of currently available detectors and tunable local oscillators in the frequency range of interest.

In a receiver following this approach (see figure), a preamplified incoming microwave signal is up-converted by the method described in the preceeding article. The frequency up-converter exploits the nonlinearity of the electromagnetic response of a whispering-gallery-mode (WGM) resonator made of $LiNbO_3$. Up-conversion takes place by three-wave mixing in the resonator. The WGM resonator is designed and fabricated to function simultaneously as an electro-optical modulator and to exhibit resonance at the microwave and optical operating frequencies plus phase matching among the microwave and optical signals circulating in the resonator. The up-conversion is an efficient process, and the efficiency is enhanced by the combination of microwave and optical resonances.



A **Microwave Signal Is Up-Converted** to an optical signal, then filtered or otherwise processed photonically before being detected.

The up-converted signal is processed photonically by use of a tunable optical filter or local oscillator, and is then detected. Tunable optical filters can be made to be frequency agile and to exhibit high resonance quality factors (high Q values), thereby making it possible to utilize a variety of signal-processing modalities. Therefore, it is anticipated that when fully developed, receivers of this type will be compact and will be capable of both wide-band and narrow-band signal processing. Thus, one compact receiver of this type would afford the functionality that, heretofore, could have been obtained only by use of multiple heterodyne microwave receivers.

This work was done by Andrey Matsko, Lute Maleki, Vladimir Iltchenko, Nan Yu, Dmitry Strekalov, and Anatoliy Savchenkov of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-45313