INTERFEROMETRY

S. Donati, G. Giuliani, E. Randone

Area: Optoelectronics and Photonics

Feedback of lightwave from a remote reflector into the laser cavity has been demonstrated in our laboratory since 1977, and subsequently developed as an original method to perform interferometric measurements. A He-Ne laser was used in the early implementations of the feedback interferometer, while more compact, reliable and rugged laser diode sources are now employed. Feedback interferometry (also known as self-mixing interferometry) is attractive because it performs subwavelength resolution by a very simple optical configuration, since the beam is inherently self-aligned and in most cases no optical elements are required but a collimating objective. A cooperation has been carried out with Ecole des Mines de Nantes, and other academic and industrial partners, and several prototypes of interferometers have been developed as prototypes for industrial applications, based on the injection modulation. This activity has received funds from the European Community (Brite-Euram Selmix project). The research has produced a laser vibrometer performing a sensitivity of 50 pm/$\sqrt{}$Hz and a measuring bandwidth of 70 kHz. A dynamic range of 300 micrometer has been obtained by implementing a feedback loop acting on the laser current supply to lock the interferometer to half fringe. Last, feedback interferometry has proven to be a useful tool for the characterization of MEMS, as explained in another section. Worth to mention, self-mixing interferometry is described in detail in a textbook on Electrooptical Instrumentation by S. Donati, which has been translated in Chinese [3] and is used in several PR China Universities.

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OPTICAL TECHNIQUES FOR MICROMACHINED DEVICES

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Area: Optoelectronics and Photonics

The research activity on MEMS (Micro-Electro-Mechanical-System) and MOEMS (Micro-Opto-Electro-Mechanical-System), in collaboration with ST Microelectronics (STM), Milan, Italy, and Università di Pisa, has been continued also in 2006. We have tested optical microstructures, fabricated by STM, called Venetian blind micromirrors, consisting in a variable blazed grating where the reflecting sections can be tilted with respect to the plane of the substrate, by means of electrostatic actuation. A laser diode feedback interferometer, has been efficiently applied for dynamic and quasi-static characterization measurements. In 2006, we have also continued the activity related to the optical characterization of one dimensional, vertical photonic crystals, fabricated by the Università di Pisa by photo-electro-chemical-etching of silicon. Photonic band gaps at a wavelength of about 1.5 micrometers have been experimentally detected, thus demonstrating the potentiality of these materials as building blocks for passive components, to be used in optical communication networks.

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DYNAMIC BEHAVIOUR OF SEMICONDUCTOR LASERS

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Area: Optoelectronics and Photonics

In recent years, semiconductor lasers have been studied in their dynamical behaviour to unveil new modes of operation as well as to understand more basic phenomena underpinned in this type of optical source. The study of semiconductor laser properties is of great interest for their deployment in practical systems for telecommunications and sensing. We have studied the experimental characterization of laser "linewidth enhancement factor" (or alfa-factor), a parameter affecting both the linewidth and hence the spectral purity of the oscillation, but also important in the regime of modulation and locking between two coupled laser sources. We have devised and applied a new method, very easy to implement, for the measurement of the alfa-factor, that is based on operation in presence of a controlled moderate optical feedback. The main results has been the measurement of the linewidth enhancement factor of a Quantum Cascade Laser (QCL) emitting at 5.5 μm. QCLs are supposed to have an alpha-factor around zero. Our measurement shows for the first time that the alpha-factor for a QCL has indeed a low absolute value around threshold, but it increases above threshold, reaching a value as large as 2.7. The linewidth enhancement factor has also been measured for conventional interband lasers using the optical feedback method, showing some variations above threshold, although not as large as for the QCL. Detailed experimental and theoretical investigations have been carried out on semiconductor lasers based on a ring cavity, that are very promising for all-optical switching and all-optical memory applications, as they can operate in a directional bistable regime. The measured linewidth of practical semiconductor ring lasers (SRLs) lies in the range of a few tens of MHz; these values can be further reduced by proper device design. The switching between the two counter-propagating modes in a SRL in the directionally bistable regime has been investigated theoretically. The switching can be induced by injecting an external light into the device, and switching times as low as 10 ps can be achieved.

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CMOS TRANSCEIVERS AND BUILDING BLOCKS FOR RF APPLICATIONS

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Area: Integrated Circuits and Systems

During the year 2006 the group ha continued to carry on research within the frame of the the National project FIRB "Enabling Technologies for Reconfigurable Terminals" which was successfully completed in May. The aim of the project is the definition of the architecture and the realization of the key enabling blocks of a Multi-standard/Multi-mode transceiver capable to support services for Wireless Wide Area Networks like GSM DCS 1800 and UMTS, for Wireless Local Area Networks like 802.11a,b,g and Wireless personal Area Networks like Blue-Tooth. Specifically the activity has regarded two main areas. First the characterization of a multi-band LNA operated in a feedback configuration through an integrated transformer. Second the design and measurement of an All Digital PLL (ADPLL) intended to be used within a directly modulated transmitter for UMTS applications. For these and several other Multi-standard/Broadband circuit blocks the group has continued to study new or improved topologies. In particular a new matrix based Time to Digital Converter (TDC) and a front-end circuit for Ultra Wide Band (UWB) applications are under development. In this section the key ideas for each realized circuit are provided and the results of the characterization are reported.

Multimode Reconfigurable Wireless Terminals

We are witnessing a merging between communication, and computing toward a broad connection for all at any time and any place. Within this framework, various different wireless networks (for wide, local and personal area) will be seamlessly interconnected in a way that, while being completely transparent, best suites the user. To operate in a such a way, new terminals that support a wide range of communication standards (each with a different RF frequency, bandwidth, modulation etc) in addition to Bluetooth (BT), GPS, FM-radio and HDTV are required. The new terminals should support both horizontal handover, i.e. switching between different modes of the same system, and vertical handover, i.e. switching between different systems. Furthermore, in the future, they should adapt themselves to the channel conditions and user demands to provide the quality of service (QoS) required with the minimum power consumption. Only adaptive circuits able to reconfigure themselves within the handover time can enable a single transceiver covering all the standards with the lowest cost, form factor and power consumption. Our target is to cover GSM, WCDMA, BT, and WLANs. GSM and WCDMA dominate voice and mixed voice/data services, IEEE 802.11a/b/g are the winners for high data-rate internet access and BT enables short distance wireless connection with other devices. This framework has been depicted by the 3GPP that has foreseen, for example, solutions for interoperability among heterogeneous systems. The activity, supported by the Italian Project FIRB "Enabling technologies for reconfigurable wireless