introducing the

Optoelectronics Group
the Pavia Optoelectronics Group, 2006

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Andrea Fanzio
(Technician)

New Young Graduate

Optoelectronics Group, University of Pavia
Research Activity

- since 1980: Photodetection, Electro-Optical Instrumentation, Fiber Optic Sensors, fiber passive components, noise in Optical Amplifiers


- **SYNCHRONIZATION OF CHAOTIC LASERS** – and application to cryptograph OCCULT (2001-2004) PICASSO (2006-)

- **SEMICONDUCTOR RING LASERS** – gyros, mode dynamics, switching regimes ASI and Telecom (2002-2005) IOLOS (2006-)

- **MEMS & MOEMS CHARACTERIZATIONS** – gyroscopes, accelerometers and mirror arrays FIRB project (2003-2005)

- **SINGLE-PHOTON AVALANCHE-PHOTODIODE (SPAD) ARRAY** - a 3-D camera MEGAFRAME (2006-)
Group Publications/Awards

- 2 books (Prentice Hall)
- 350 papers in refereed Journals
  (of which >40% co-authored by our students !!)
- 4 international patents
- 12 Conferences Chaired
- >500 citations of seminal papers
- 4 fellowships (IEEE, OSA)
- 9 awards
Tematiche di ricerca per attività di tesi

Donati$ - Randone& - Martini*

• SPAD-array per fotografia ultrarapida 3D
  - Matrici di microlenti per recupero del Fill-Factor $*$
  - Accuratezza di misure di tempo con SPAD $*$

• Interferometria a Self-Mixing
  - Sviluppo strumentazione di misura$&
  - Comportamento agli alti livelli di iniezione$&
SPAD array - developing the 3D camera
- each pixel = a pulsed telemeter.

![Diagram of SPAD array and 3D camera setup]

Optoelectronics Group, University of Pavia
Pixel Design (IRST)

Biasing: quenching diode-connected transistor limits the avalanche current

Events Counter: in-pixel 17bit digital events counter, based on a LFSR pseudorandom number generator.

- A serial reading of an entire row is allowed connecting the counters together
- Optional external counting is allowed
Self-Mixing Interferometry

- **Interferometry from optical feedback in SLs**

  \[ \mathbf{P}_{\text{in}} \rightarrow \mathbf{R}_{2} \text{ Monitor PD} \rightarrow \mathbf{P}'_{\text{out}} = \frac{P_{0}}{A} \rightarrow \text{Remote Target} \]

  \( A = \text{round-trip optical power attenuation} \)

  **Theory:** Lang-Kobayashi eqs.; **Output power modulation:**

  \[ P(\phi) = P_{0}[1 + m \cdot F(\phi)] \]

  - **WEAK FEEDBACK** \((A \approx 10^6)\)
  - **MEDIUM FEEDBACK** \((A \approx 10^5)\)

  ![Graphs showing self-mixing interferometry](attachment:image.png)

  - **Target displacement**
  - **Self-Mixing Signal**
  - **Time** [200ms/div]

**Optoelectronics Group, University of Pavia**
**Self-Mixing Interferometry: Applications**

- **Application to mechanical metrology**
  - **Measurement of:** Displacement, Velocity, Ranging/Distance, Vibration
- **Development of prototype instruments**


**Laser Interferometer**

- Non-contact displacement measurement
- PC interface: R232
- Sub-nanometer resolution
- Operation range: up to 1 m

The new Laser interferometer allows easy and accurate non-contact displacement measurement, with no need of placing mirrors or corner cubes on the target. The displacement is shown by an indicator in meters and the sign can be read by LaserMax™ software. A possible erroring system allows the comparison between reference targets, by overcoming the problem of signal fading.

- Principle of Operation
  - The new Laser interferometer is based on a novel and simple self-mixing interferometric scheme, and it uses a semiconductor diode laser. The Michelson interferometer configuration (consisting of a conventional laser interferometric system and a parallelized self-mixing interferometer) is repeated in the interferometer system. The self-mixing interferometer scheme is based on the coherent interference of the backscattered light from the target and a single photodiode. The target displacement is reproduced from the interferometric signal on an electronic display. The interferometer incorporates a system for monitoring the optical signal: the sensitive head incorporates a system for monitoring the optical signal. Therefore, the instrument can also be used with reference targets, without the need of a reference alignment procedure.

- Applications
  - Non-contact measurement of displacement
  - Vibration measurement

- **Laser Vibrometer**

- Non-contact measurement of vibration
- Operation range larger than 160 mHz
- Frequency range: 1 mHz - 20000 mHz

The new Laser Vibrometer allows easy and accurate non-contact vibration measurement, on all kind of surfaces (e.g., paper, label, ungrounded mobiles, etc.). It provides a readable electrical output, which is suitable for range applications (0-10 V range). The instrument operates in two modes: 1. The light spot is down to 1 Hz, and a peak-to-peak maximum vibration amplitude of 0.3 mm at 10 Hz.

- **Properties**
  - Bandwidth: 1 mHz - 20000 mHz
  - Sensitivity: 1 V/10 mHz
  - Resolution: 1 mHz
  - Accuracy: ±1% of reading
  - Measurement range: 0.1 mHz - 20000 mHz

- **Features**
  - Easy and convenient operation
  - Fast, accurate measurement
  - No need for a reference alignment
  - Non-contact measurement
  - Frequency range: 1 mHz - 20000 mHz
  - Reliable and durable

**Use**

The optical head shall be aimed at the vibration source (e.g., a standing wave in the Fabry-Perot cavity). The optical head shall be aimed at the vibration source (e.g., a standing wave in the Fabry-Perot cavity). The optical head shall be aimed at the vibration source (e.g., a standing wave in the Fabry-Perot cavity).
Tematiche di ricerca per attività di tesi
Annovazzi - Merlo - Benedetti

• Caratterizzazione ottica di dispositivi e materiali ottenuti per microlavorazione del silicio
Cristalli fotonici 1D e 2D - MEMS - MOEMS

• Crittografia ottica caotica

Tematiche di ricerca per attività di tesi
Giuliani

• Memorie ottiche ultraveloci basate su laser a semiconduttore ad anello

• Dinamica di laser a semiconduttore per la generazione di radiofrequenze