High-Speed LED Illumination

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Abstract

Fluorescence lifetime imaging microscopy (FLIM) is an advanced microscopy technique that is used to perform radiometric imaging. First, a fluorescence sample is excited with a pulse of light. Then, measurements of the fluorescence intensity are made. The rate at which the fluorescence intensity decays is called the fluorescence lifetime. Our group is using the same techniques to build a new class of integrated circuit microscopes because electronic circuits are better at filtering in the time domain than the spectral domain. Building excitation light sources for FLIM is a challenge, because the excitation light must decay more quickly than the fluorescence, which decays exponentially with time constants between 100ps and 20ns. The sub-nanosecond excitation light pulses required for FLIM can be provided by laser diodes, but affordable laser diodes are only available in a limited selection of wavelengths. We are developing a new excitation system using Light Emitting Diodes (LEDs) because they are available in a wider range of wavelengths.

Table 1: We have tested five different LEDs. Even though these LEDs emit similar wavelengths, the transfer curves differ.

<table>
<thead>
<tr>
<th>LED</th>
<th>Forward Voltage</th>
<th>Test Current</th>
<th>Donor Wavelength</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>150-16349-3-ND</td>
<td>3.4V</td>
<td>20mA</td>
<td>468nm</td>
<td>1.6x1mm</td>
</tr>
<tr>
<td>764-12189-3-ND</td>
<td>3.3V</td>
<td>20mA</td>
<td>468nm</td>
<td>1.6x4mm</td>
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<tr>
<td>P1153C1-ND</td>
<td>3.2V</td>
<td>5mA</td>
<td>477nm</td>
<td>2.5x1mm</td>
</tr>
<tr>
<td>492-22311-2-ND</td>
<td>3.3V</td>
<td>20mA</td>
<td>477nm</td>
<td>1.6x4mm</td>
</tr>
<tr>
<td>P1159C5-ND</td>
<td>2.9V</td>
<td>5mA</td>
<td>477nm</td>
<td>2.5x1mm</td>
</tr>
</tbody>
</table>

Figures:
- Figure 1: Fluorescence Lifetime is a measure of the exponential decay rate of fluorescence following pulsed excitation.
- Figure 2: Small, Surface-Mount LEDs are used because it is expected that they will be faster than larger, higher-power LEDs.
- Figure 3: We built a test board using copper tape on a copper-clad fiberglass board to create a consistent system for measuring the frequency response of the LEDs.
- Figure 4: We have measured the DC response of each laser diode to determine where to bias the devices for high-frequency measurements.

Research Objectives

- Measure LED Frequency Responses
- Develop High-Frequency LED Circuit Model
- Develop High-Frequency Circuit Model of LED
- Design Pulsing Circuit
- Build Pulsed LED Illuminator

Future Work

- Design of Pulsing Circuit
- Testing of High-Speed LED Illuminator

Progress and Results

- We performed DC sweeps to determine proper biasing for each LED.
- We then used the test board shown in Fig. 3 to perform high-speed characterization.

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