In this six-part blog series, we are examining the most crucial parameters in APD detectors. No matter whether you're working in laser radar, data transfer, or even biomedical analysis applications, selecting the right laser is intertwined with how well you understand the ways these parameters mutually interact.

Today's installment focuses on ***the wavelength parameter****: How should you weigh wavelength performance against total cost? To answer this question, we analyze important aspects of wavelengths—such as range and performance—and their interactions with other APD parameters.*

Why Wavelength?

When selecting the right laser for your application, your first consideration often begins with wavelength range. Spanning from 300 – 1100nm, wavelength ranges can be broken down by the APD material: Silicon from 300 – 1100nm, Germanium from 800 – 1100nm and InGaAs from 900 – 1100nm. Choosing a material is often a question of cost (e.g., Silicon is cheaper than InGaAs), although it is important to keep in mind the need for specific application. For example, 1550nm lasers (available via Geranium or InGaAs) perform better in fog and rain; they can also carry higher resolution and higher eye safety.

It is important to note that wavelengths are controlled via several factors. One important factor is operating temperature, as this will affect the size of wavelength: the hotter the APD, the shorter the wavelength. Additionally, anti-reflective coating and your implementation process will also affect the range and power of your APD's wavelength.

SWAP-c

Of course, if APD decisions were simply a question of performance, the answer would be straightforward. However, the fact is that there are a number of tradeoffs one must make when selecting a wavelength that will greatly influence your APD selection. Some of these tradeoffs we have already highlighted: by choosing Silicion as opposed to InGaAs, you save on cost but sacrifice >1100 – 1700nm in range. Power needs will also make a sizeable difference, as your application can determine your output requirements. Accordingly, there are four factors to consider with wavelength:

Size: Depending on your application, selecting the size of your APD boils down to the minimal surface size necessary to achieve your results. Small-area APDs are more economical than larger detectors since more chips can be manufactured per wafer. Of course, it may be advantageous to use a larger APD depending on application: special modifications to small APDs are often not worth the larger trade-off.

Weight: Operating hand in hand with size, the weight of your APD is influenced by need and application. The more surface area and power you need, the more your APD will weight and the more it will cost. Additionally, attempting to meet specific needs (adding optics) will also increase weight.

Power: How powerful do you need your APD's wavelength? Determined by the photons required on your target, power is a function of stripe width, chip length, number of lasing cavities, number of chips (stacked or bilinear configuration) as well as divergence of the beam. This can also be influenced by laser design and inherent efficiency—essentially, power will come down to need and budget.

Cost: As we have previously noted, material is a key influencer of cost. Silicon offers the most extensive APD product range; however, InGaAs have significantly lower noise characteristics and additional application advantages (albeit a higher price tag), while Germanium is recommended for cost-sensitive applications or in systems exposed to electromagnetic interference with high secondary amplifier noise.

APD Wavelength Applications

Because APDs are utilized in a myriad of applications, the selection of both range and material will vary depending on your project. In laser range finders, for example, precise APD wavelengths are a good choice due to their high sensitivity and quick response times. Additionally, because these APDs can operate with lower light levels and shorter laser pulses, they can make range finders more eye safe. This is similarly the case with microscopy and biomedical applications that require a high degree of precision. In the past decade, we have also seen APD wavelength considerations factor into automotive applications, such as automatic cruise control, obstacle avoidance and blind spot detection. With the importance of APD wavelength and its bearing on application decisions, these considerations will only continue.

Interaction Highlights

As the first link in our APD parameter chain, wavelength is a foundational parameter that affects all other parameters—and is, in turn, affected by them. In this article, we will look to highlight two key parameters and their interactions with wavelength. Later in our series, we will devote full articles to each parameter:

> **Dark Current:** Often a concern when it comes to noise, dark current is the current running thorough the APD when there is no incident light. When operating in an APD, dark current increases power consumption, cooling requirements, along with read-out challenges. As we have seen, increases in temperature and power consumption can affect the ability of wavelengths to perform. Any impact to dark current, therefore, will naturally affect wavelength.
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> **Capacitance:** The interactions surrounding this parameter are a bit more apparent. Max capacitance of an APD is critical as it affects the overall ability of the APD to store an electrical charge. Without the ability to access this energy, the APD cannot produce a wavelength. Consequently, the higher the max capacitance of the APD, the more power is able to be produced by the wavelength.

When it comes to selecting an APD, wavelength will often be your first consideration, but that does not mean it is the only factor for APDs. In our next article, we will discuss **active area** and its importance in the APD chain—this includes its relationships with dark current as well as to wavelength. By understanding the mutual interactions of APD parameters, it will help you to understand the significance of each of your purchasing decisions.