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On the Theory of Intrinsic Wavelength-sensing Capability of Crystalline Silicon

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This article discusses the theoretical aspects related to the intrinsic wavelength-sensing capability of silicon. The sensing capability is attributable to the wavelength dependence on the depth to which radiation penetrates the material. Can devices fabricated in silicon utilize this phenomenon in sensing multiple wavelengths for applications such as spectrometers? It is theoretically demonstrated that the drawbacks that arise in sensing multiple wavelengths may not be solely due to limitations in the device geometry and design, but also due to the fundamental material properties of silicon themselves. Using ideal device equations, it is shown that the set of linear equations that needs to be solved to extract the spectral information of light from dc photocurrent data is severely ill-conditioned. The extent of "ill conditioning" increases approximately exponentially with increasing number of wavelengths. It is also shown that the modulated, instead of dc, photocurrent measurements may lead to smaller condition numbers, and therefore can be used for detection with better accuracy and wavelength resolution.

1. Introduction

Vision of computers for image processing, and of robots for automated manufacturing processes in an industrial environment, is a rapidly growing field of research in several engineering disciplines. In most practical cases, the vision of such