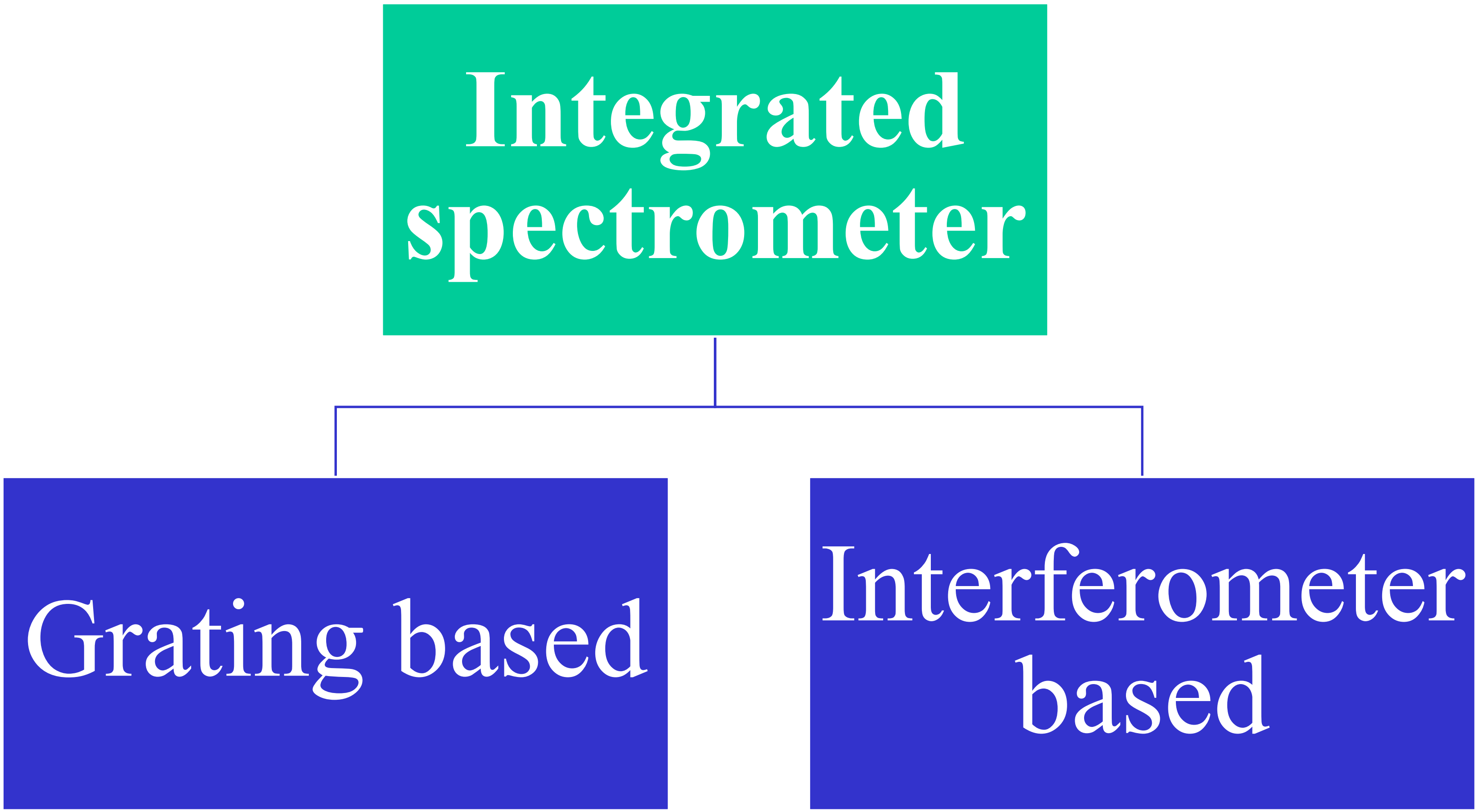
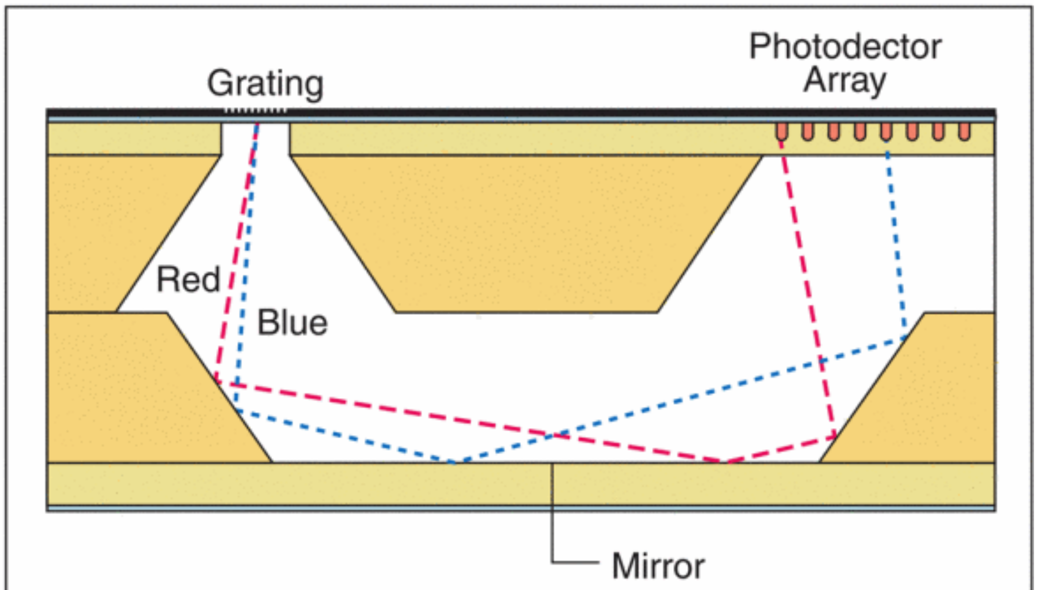
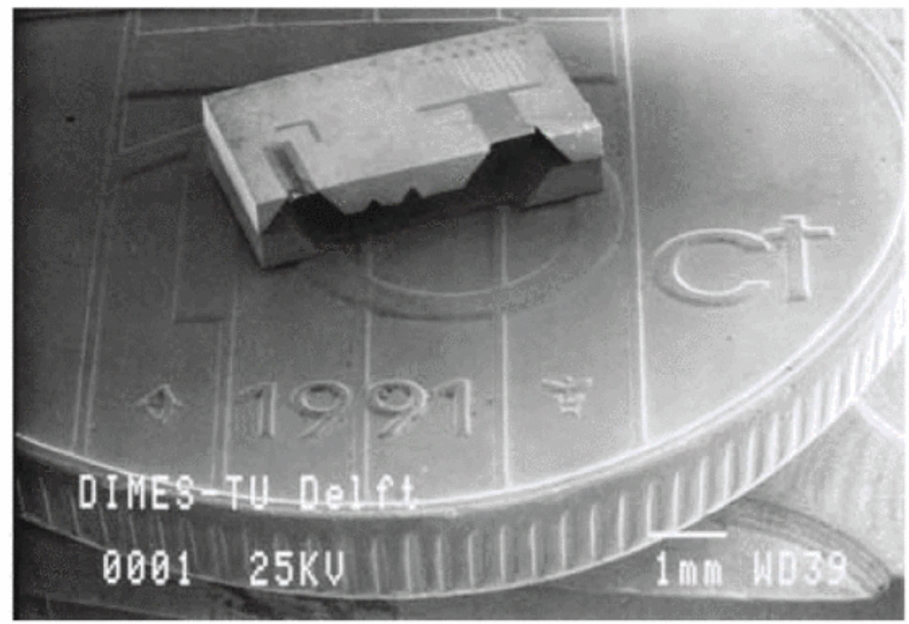

Integrated spectrometer
Grating based
Interferometer based

Grating based Integrated spectrometer



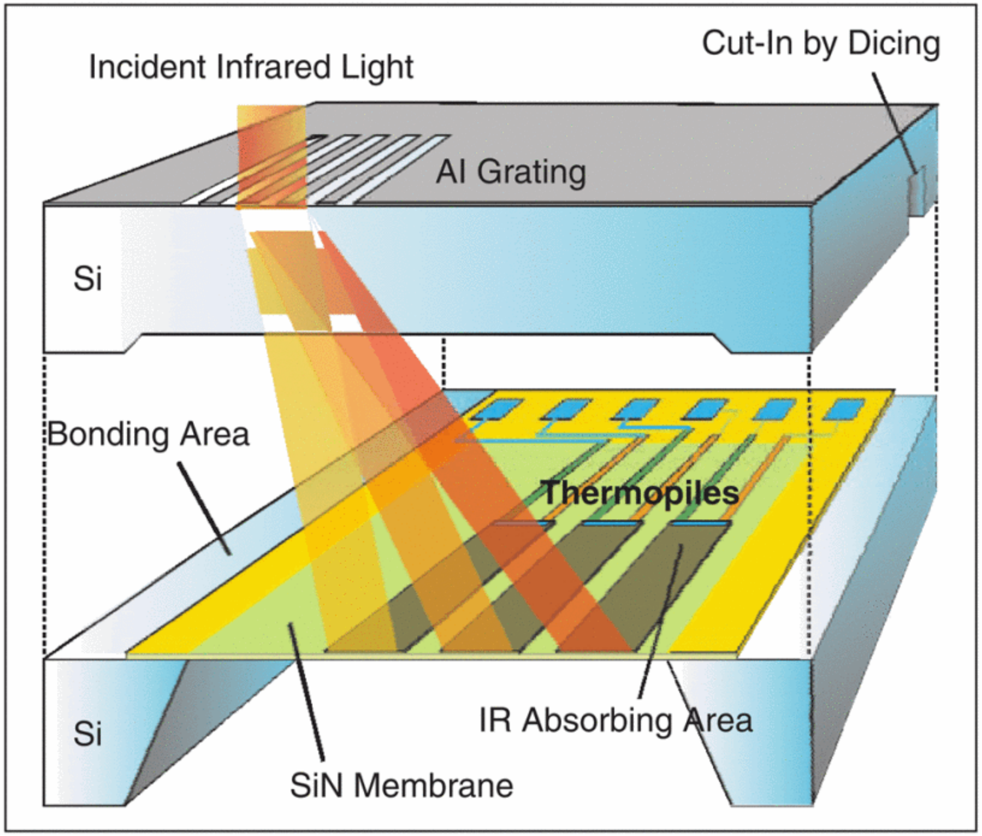
(a)



(b)

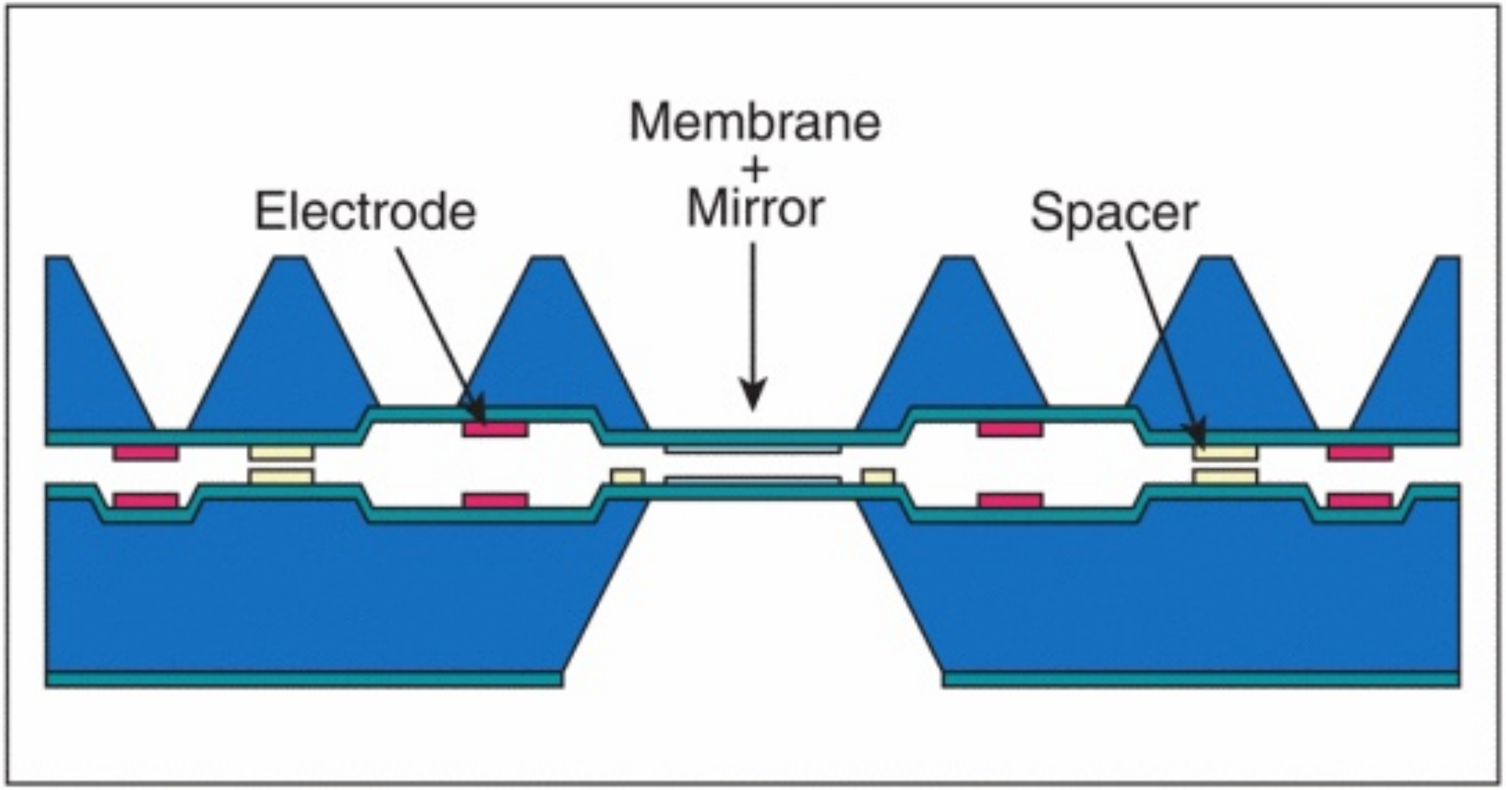
Seong-Ho Kong, J. H. Correia, G. de Graaf, M. Bartek and R. F. Wolffenbuttel, "Integrated silicon microspectrometers," in *IEEE Instrumentation & Measurement Magazine*, vol. 4, no. 3, pp. 34-38, 2001.

Grating based Integrated spectrometer



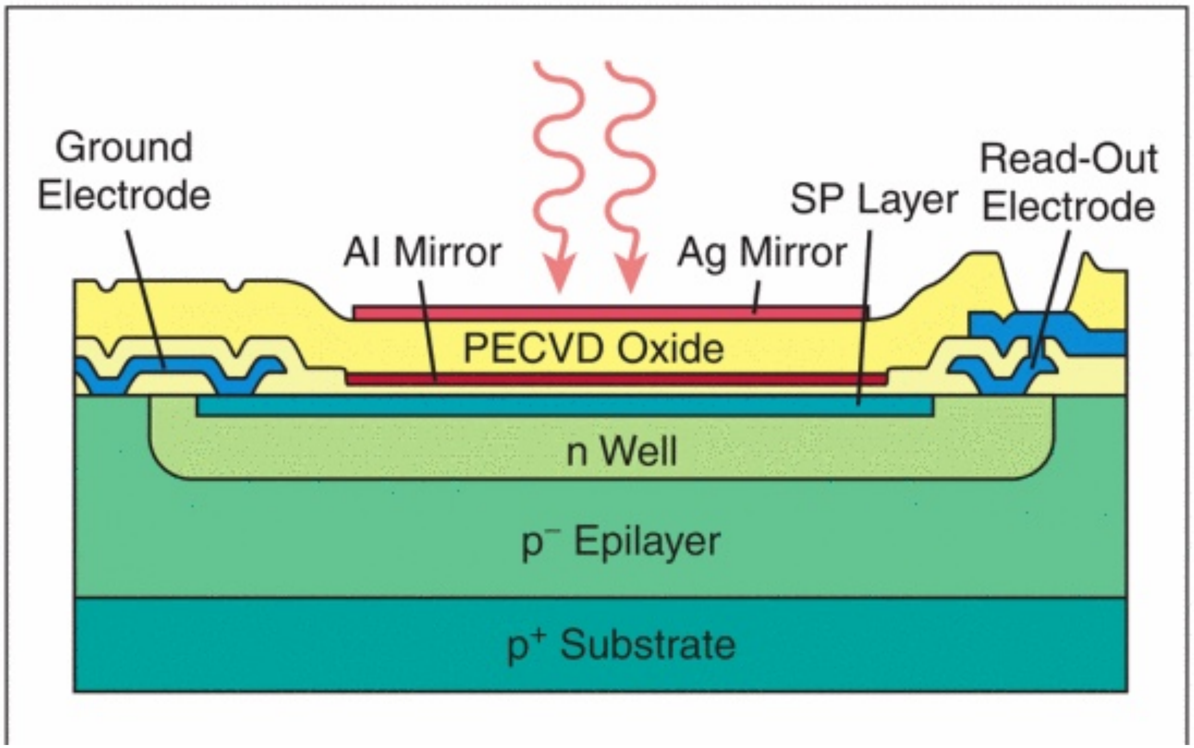
Seong-Ho Kong, J. H. Correia, G. de Graaf, M. Bartek and R. F. Wolffenbuttel, "Integrated silicon microspectrometers," in *IEEE Instrumentation & Measurement Magazine*, vol. 4, no. 3, pp. 34-38, 2001.

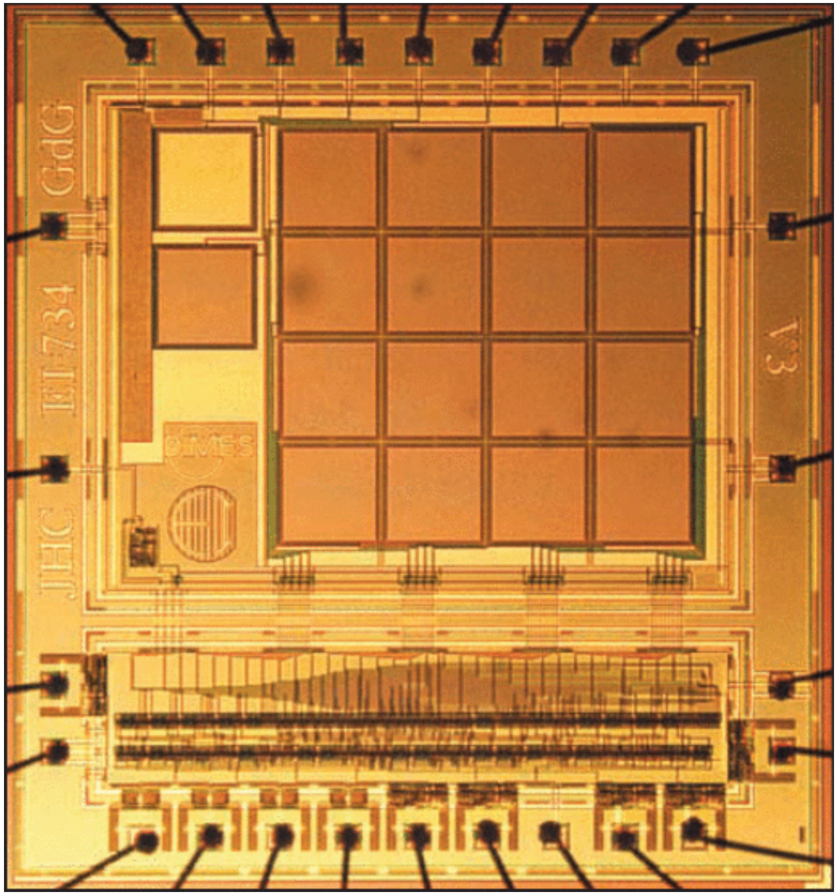
Fabry-Perot Interferometer spectrometer



Seong-Ho Kong, J. H. Correia, G. de Graaf, M. Bartek and R. F. Wolffenbuttel, "Integrated silicon microspectrometers," in *IEEE Instrumentation & Measurement Magazine*, vol. 4, no. 3, pp. 34-38, 2001.

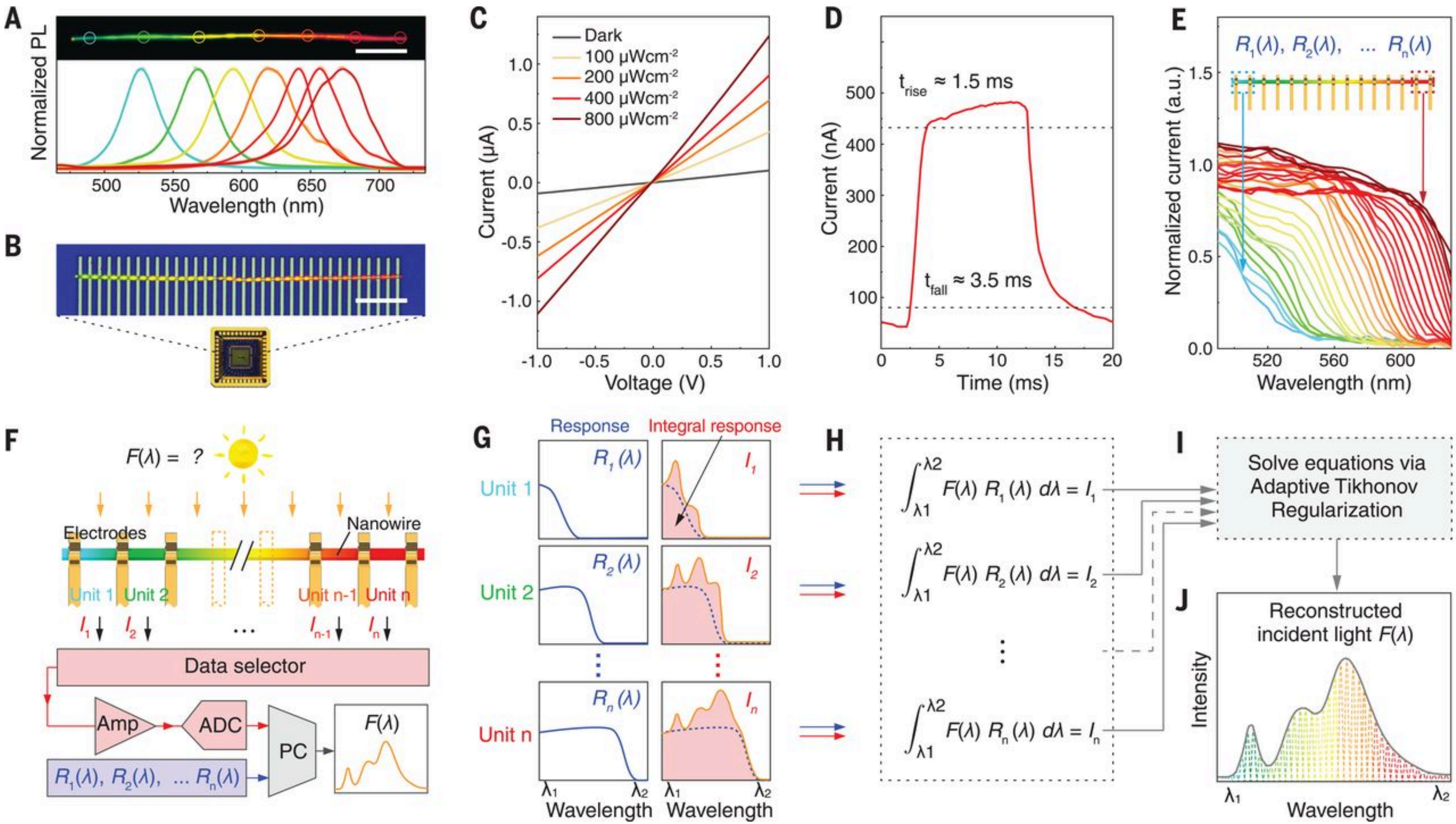
Fabry-Perot Interferometer spectrometer





1. R.F. Wolffenbuttel, *Silicon Sensors and Circuits: On-Chip Compatibility.*, 1996.
2. H. Correia, et al., "Single-chip CMOS optical micro interferometer", *Sens. Actuators A Phys.*, vol. 82, pp. 191-197, 2000.

Ultra-compact dispersion element free computational spectrometer (detector only)



$$\int_{\lambda 1}^{\lambda 2} F(\lambda)\, R_1(\lambda)\, d\lambda = I_1$$

$$\int_{\lambda 1}^{\lambda 2} F(\lambda)\, R_2(\lambda)\, d\lambda = I_2$$

$$\vdots$$

$$\int_{\lambda 1}^{\lambda 2} F(\lambda)\, R_n(\lambda)\, d\lambda = I_n$$

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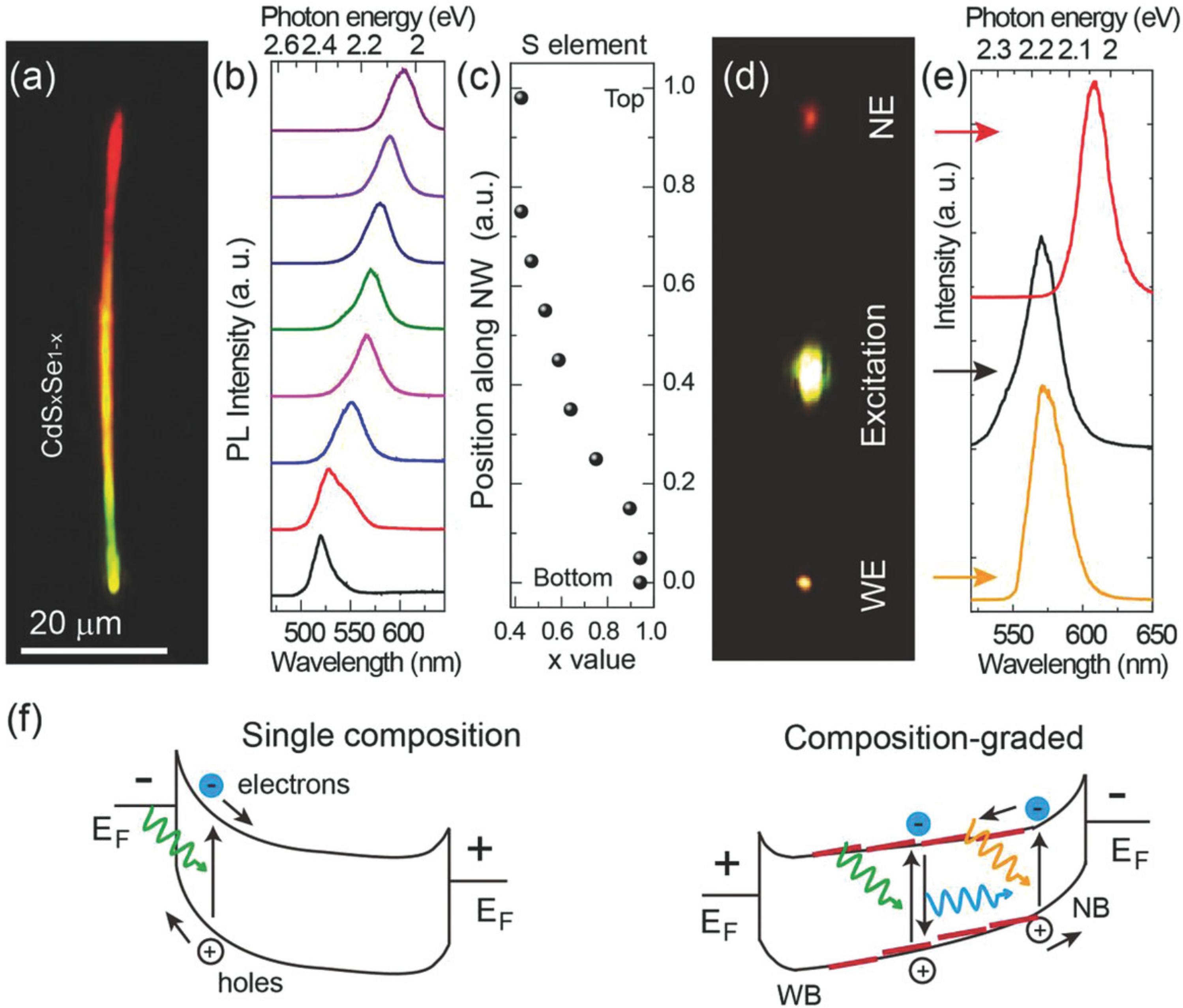
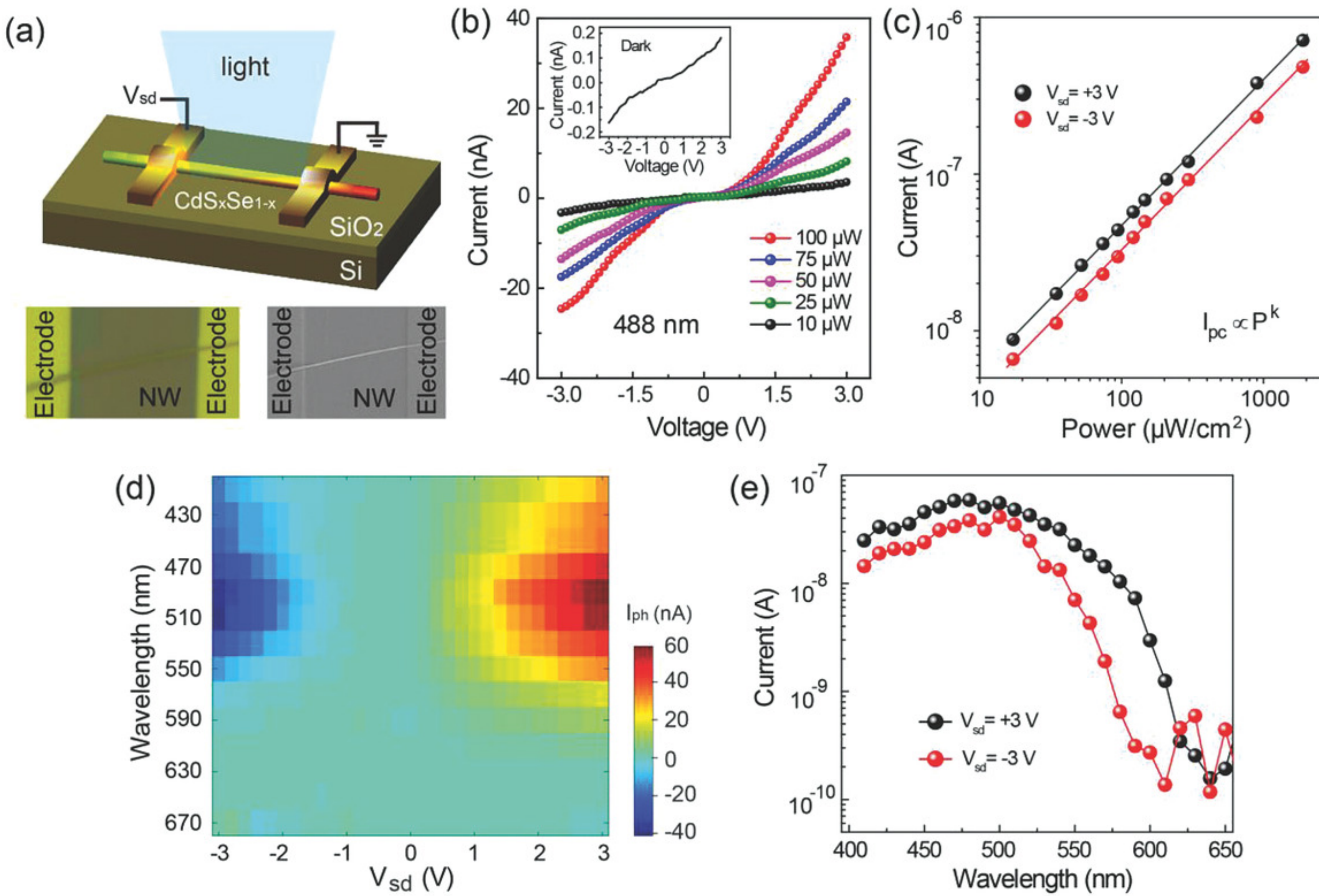
Wavelength Selective Photodetectors Integrated on a Single Composition-Graded Semiconductor Nanowire

$CdS_{0.94}Se_{0.06}$ to $CdS_{0.43}Se_{0.57}$



Advanced Optical Materials, Volume: 6, Issue: 12, First published: 03 April 2018, DOI: (10.1002/adom.201800293)

Wavelength Selective Photodetectors Integrated on a Single Composition-Graded Semiconductor Nanowire



R is 1.03×10^{3} A W^{-1} with 488 nm at 75 μW cm^{-2}

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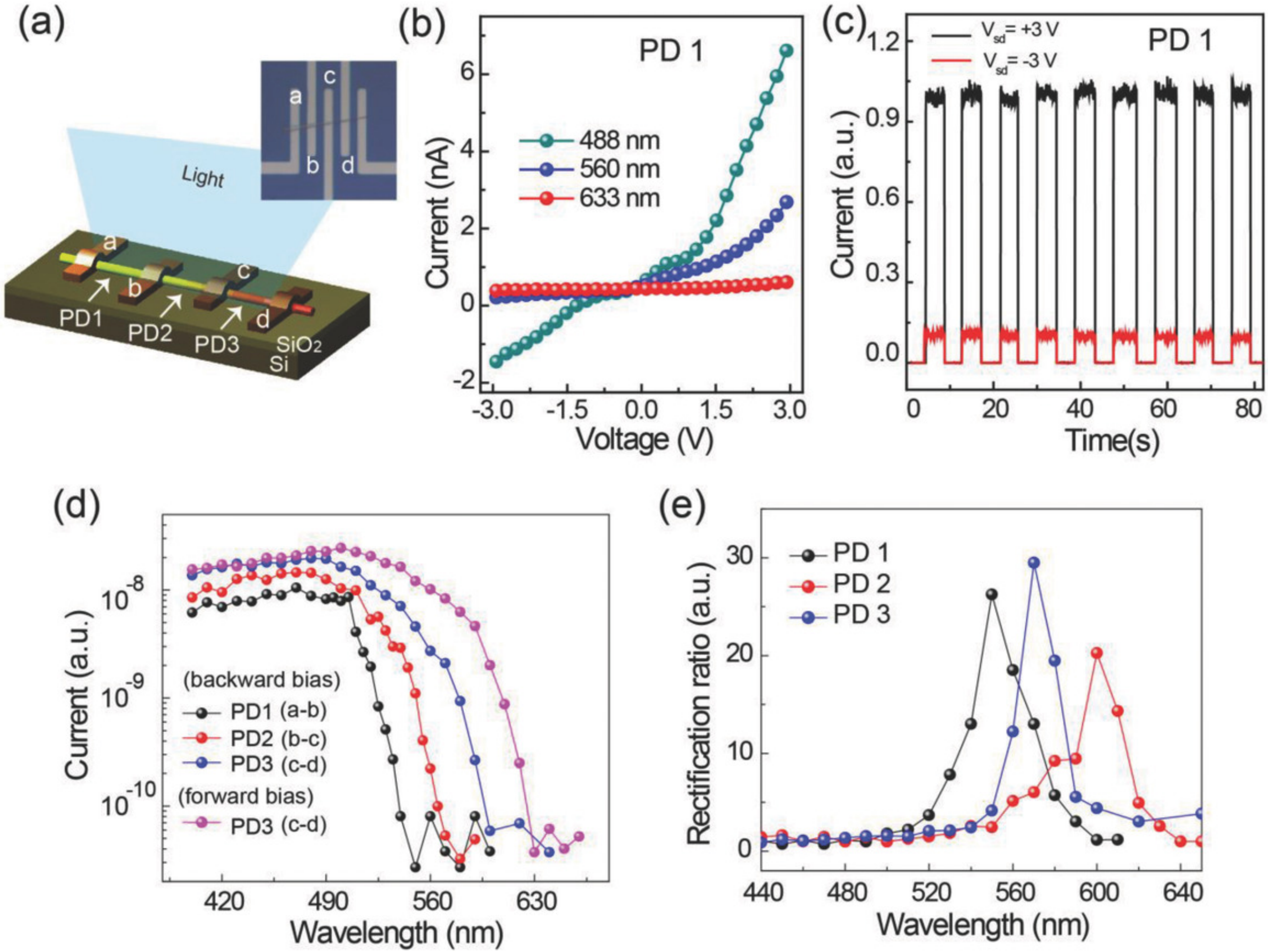
Wavelength Selective Photodetectors Integrated on a Single Composition-Graded Semiconductor Nanowire



Advanced Optical Materials, Volume: 6, Issue: 12, First published: 03 April 2018, DOI: (10.1002/adom.201800293)

Single-nanowire spectrometers

by Zongyin Yang, Tom Albrow-Owen, Hanxiao Cui, Jack Alexander-Webber, Fuxing Gu, Xiaomu Wang, Tien-Chun Wu, Minghua Zhuge, Calum Williams, Pan Wang, Anatoly V. Zayats, Weiwei Cai, Lun Dai, Stephan Hofmann, Mauro Overend, Limin Tong, Qing Yang, Zhipei Sun, and Tawfique Hasan

Science
Volume 365(6457):1017-1020
September 6, 2019

Fig. 1 Nanowire spectrometer design.

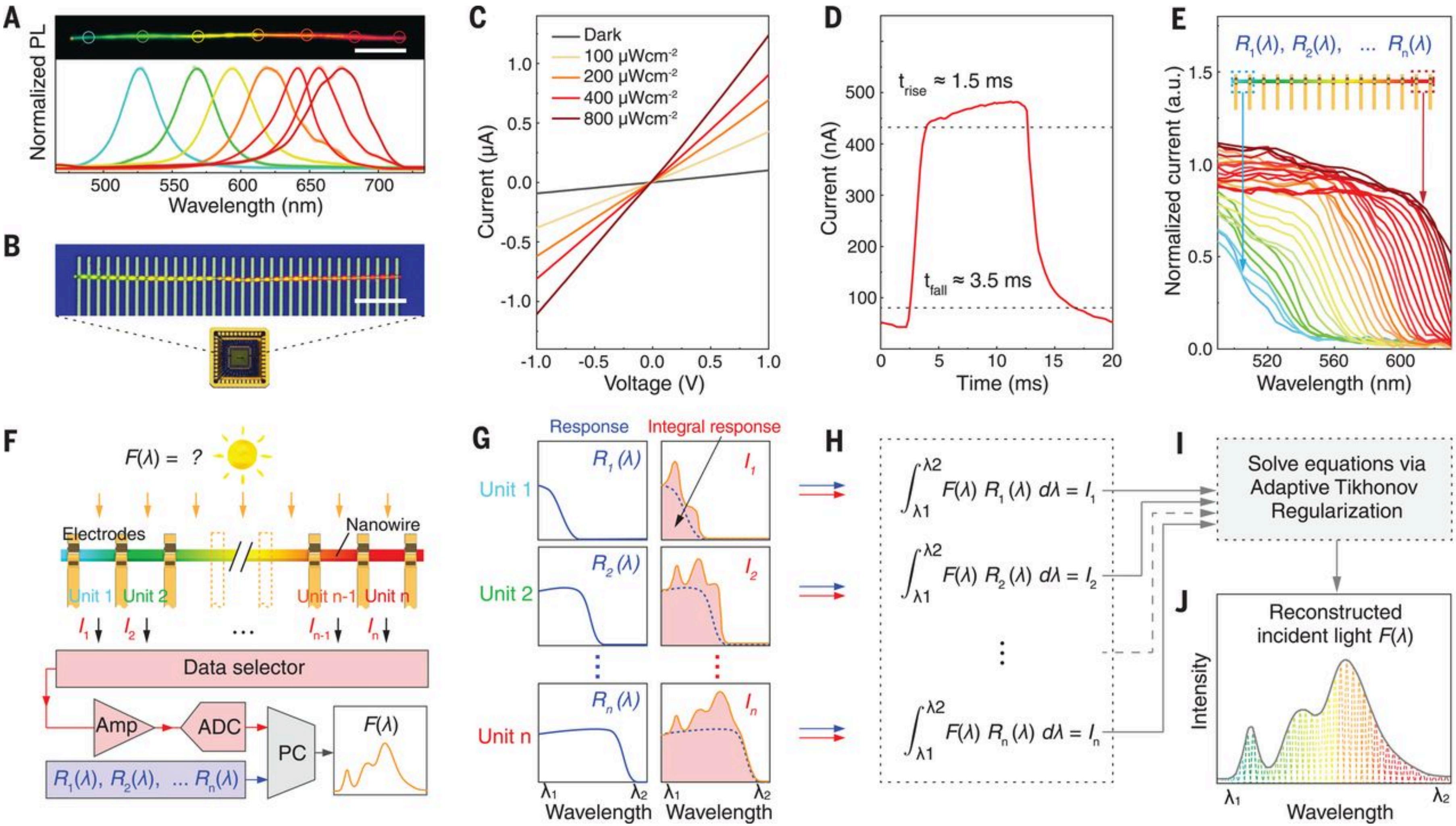
CdS_xSe_{1-x}

1.74eV 2.42 eV

CdS CdSe

~1.4×10^4 AW^{-1}

$Zn_xCd_{1-x}S_ySe_{1-y}$ (1.74 to 3.54 eV)
$In_xGa_{1-x}N$ (0.7 to 3.43 eV)
and $Si_{1-x}Ge_x$ (0.66 to 1.12 eV)



Zongyin Yang et al. Science 2019;365:1017-1020

Reconstruction Algorithm

$$\boxed{\int_{\lambda_{min}}^{\lambda_{max}} F(\lambda) R_i(\lambda)\, d\lambda = I_i \qquad (i = 1,2,3, \dots, n)}$$

$$F(\lambda) \approx \hat{F}(\lambda) = \sum_{j=1}^{m} \alpha_j \phi_j(\lambda)$$

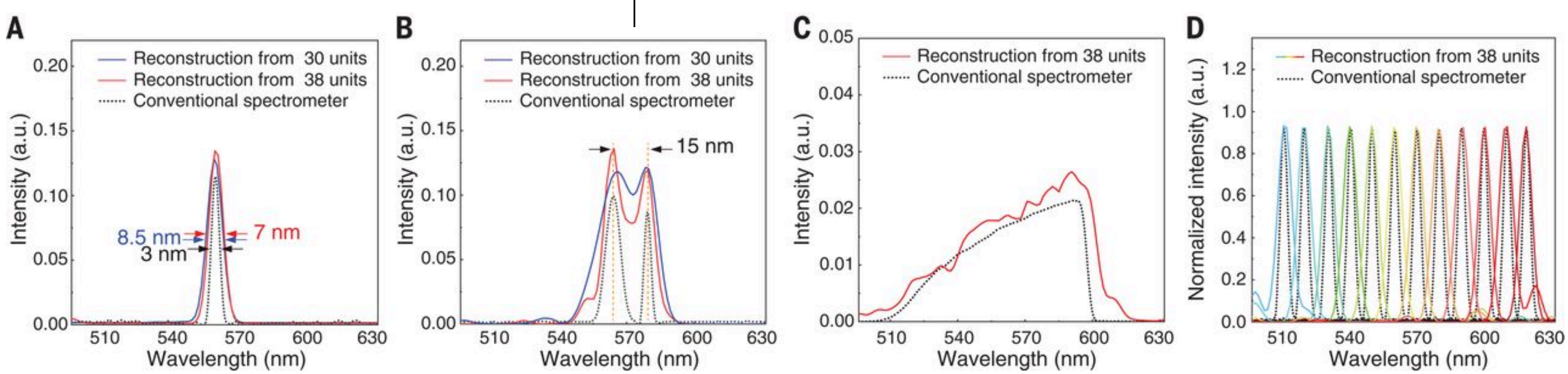
$$\varphi_j(\lambda) = \frac{1}{\sigma\sqrt{2\pi}} exp\left[-\frac{1}{2}\left(\frac{\lambda - \hat{\lambda}_j}{\sigma}\right)^2\right]$$

$$\sum_{j=1}^{m} \left(\int_{\lambda_{min}}^{\lambda_{max}} R_i\,(\lambda)\phi_j(\lambda) d\lambda\right) \alpha_j = I_i$$

$$\boxed{A\alpha = c}$$

Fig. 2 Characterization of nanowire spectrometers.

Peaks become indistinguishable once the separation is decreased to 10 nm.



Despite a reduction in footprint of about two to three orders of magnitude, such resolution is comparable to that of other visible-range spectral reconstruction microspectrometers

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Fig. 3 Scanning spectral imaging at the macroscale.

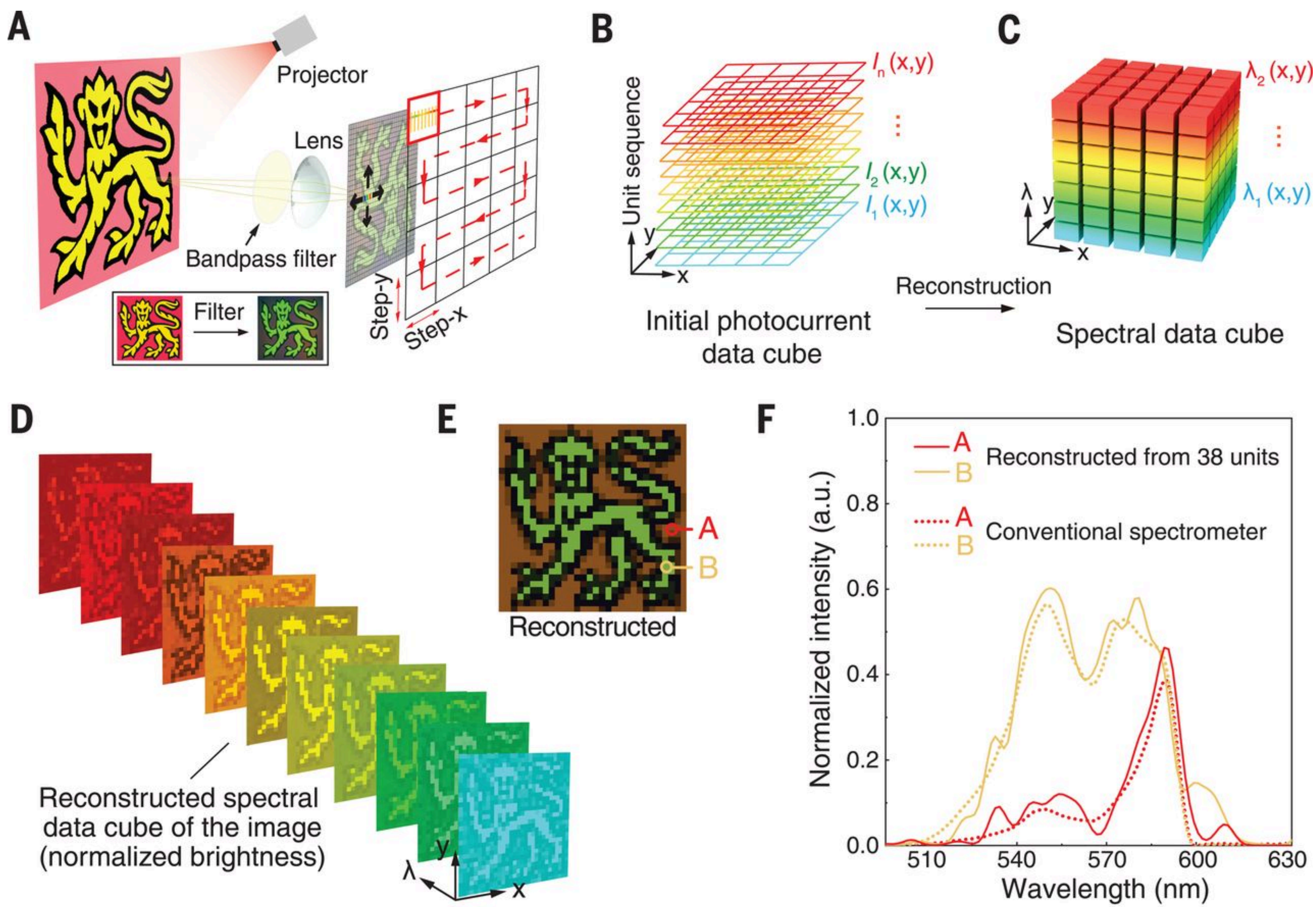

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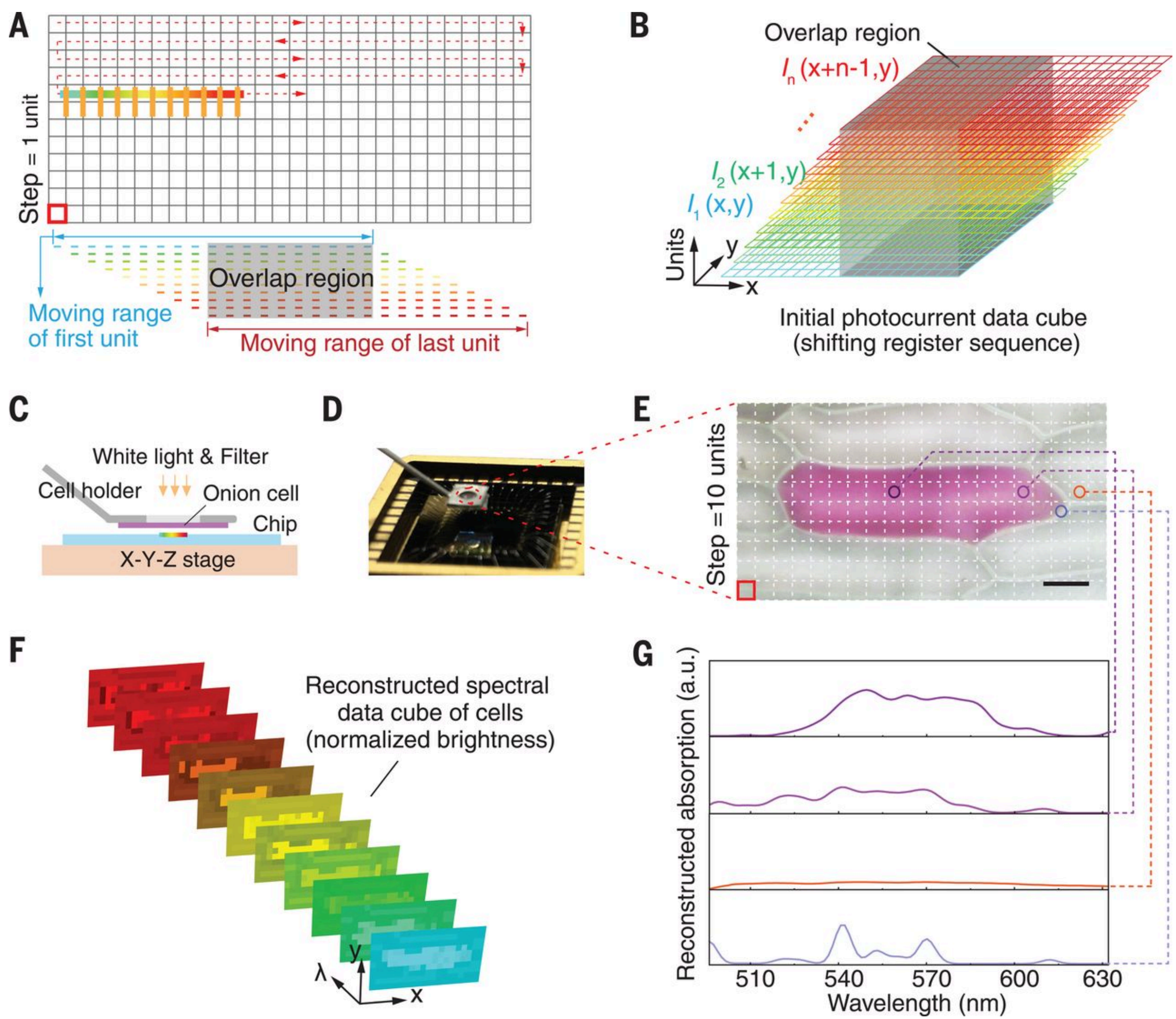
Fig. 4 Spectral imaging at the micrometer scale.



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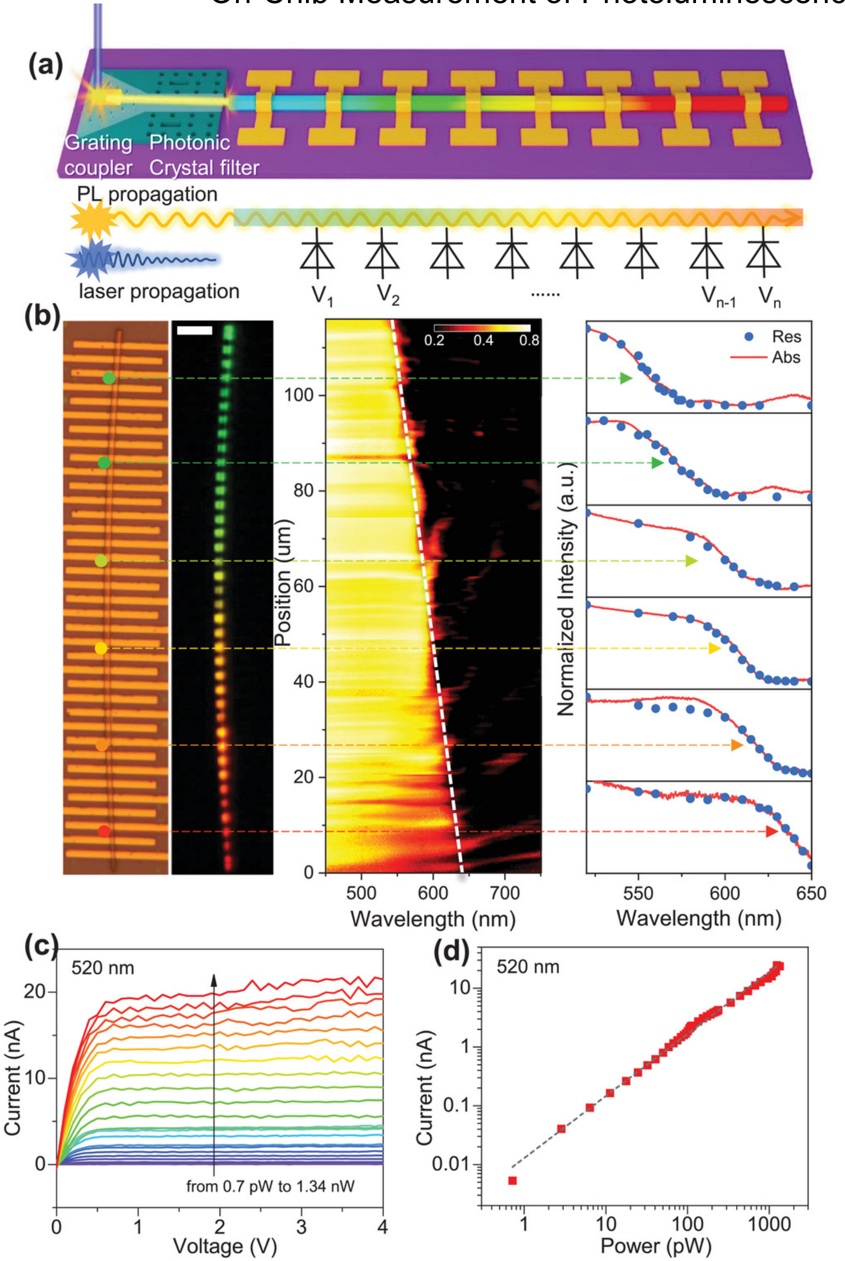
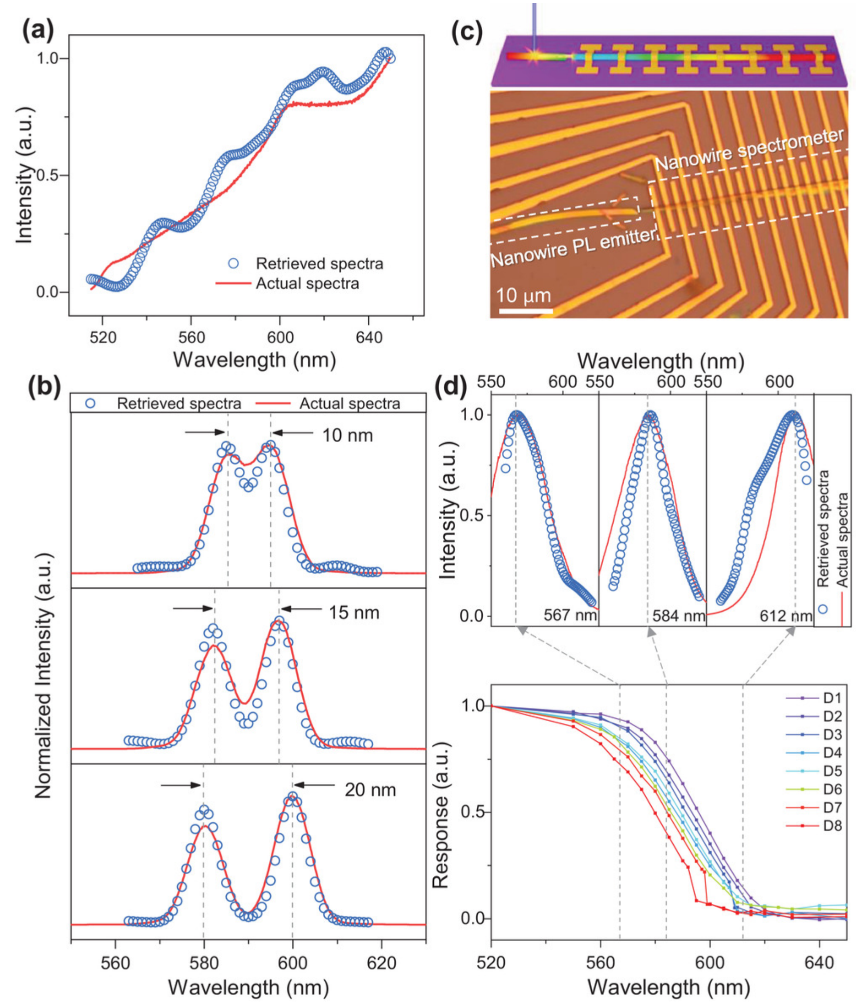
On-Chip Measurement of Photoluminescence with High Sensitivity Monolithic Spectrometer

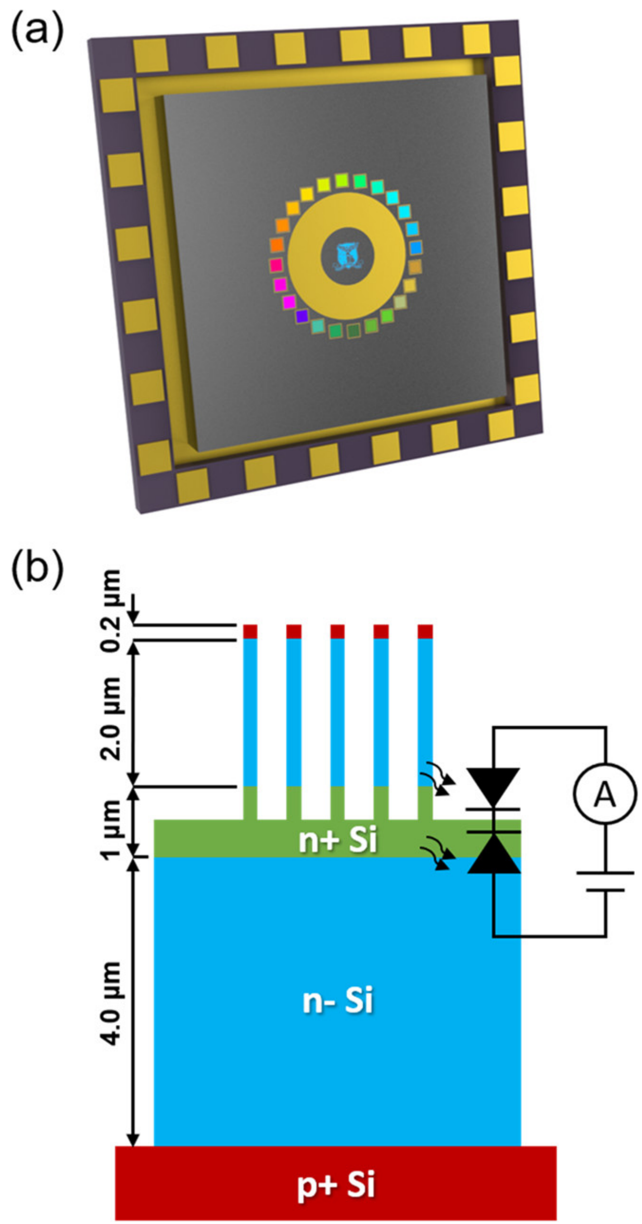


$$\begin{bmatrix} I_1 \\ \vdots \\ I_n \end{bmatrix} \approx \begin{bmatrix} R_1(\lambda_1) \cdots R_1(\lambda_m) \\ \vdots \ \ddots \ \vdots \\ R_n(\lambda_1) \cdots R_n(\lambda_m) \end{bmatrix} \begin{bmatrix} G_{\lambda_1}(\lambda_1) \cdots G_{\lambda_m}(\lambda_m) \\ \vdots \ \ddots \ \vdots \\ G_{\lambda_1}(\lambda_m) \cdots G_{\lambda_m}(\lambda_m) \end{bmatrix} \begin{bmatrix} S(\lambda_1) \\ \vdots \\ S(\lambda_m) \end{bmatrix}$$



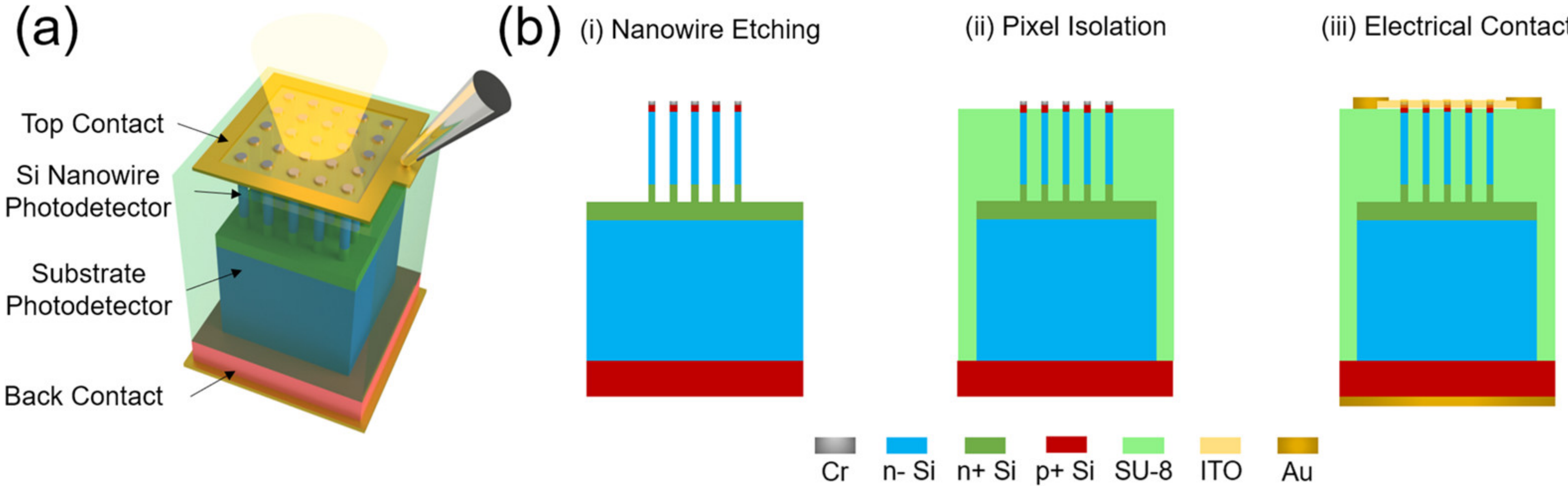
Advanced Optical Materials, First published: 06 April 2020, DOI: (10.1002/adom.202000191)

Detector-Only Spectrometer Based on Structurally Colored Silicon Nanowires and a Reconstruction Algorithm

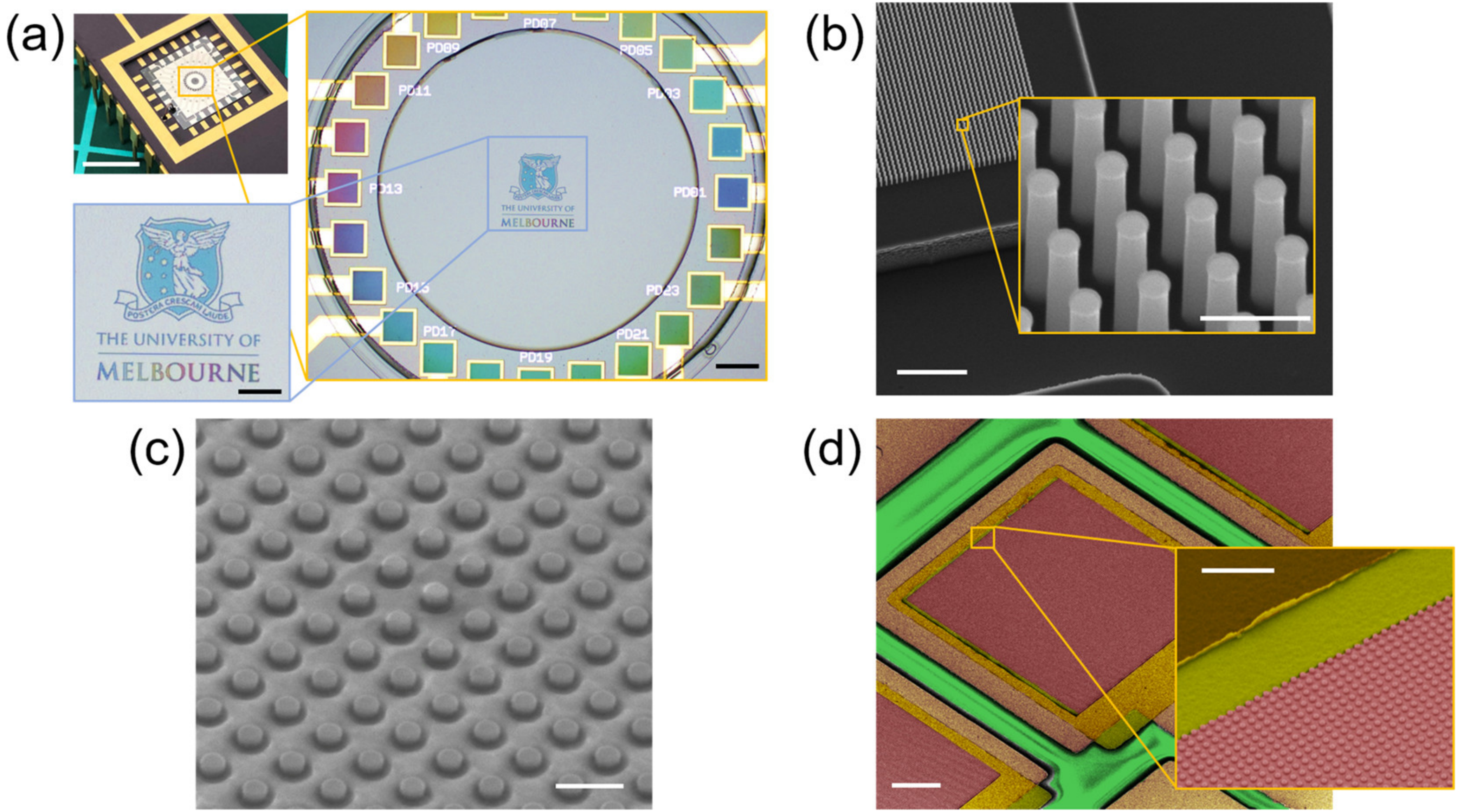


DOI: (10.1021/acs.nanolett.9b03862)

65 to 175 nm



DOI: (10.1021/acs.nanolett.9b03862)



DOI: (10.1021/acs.nanolett.9b03862)

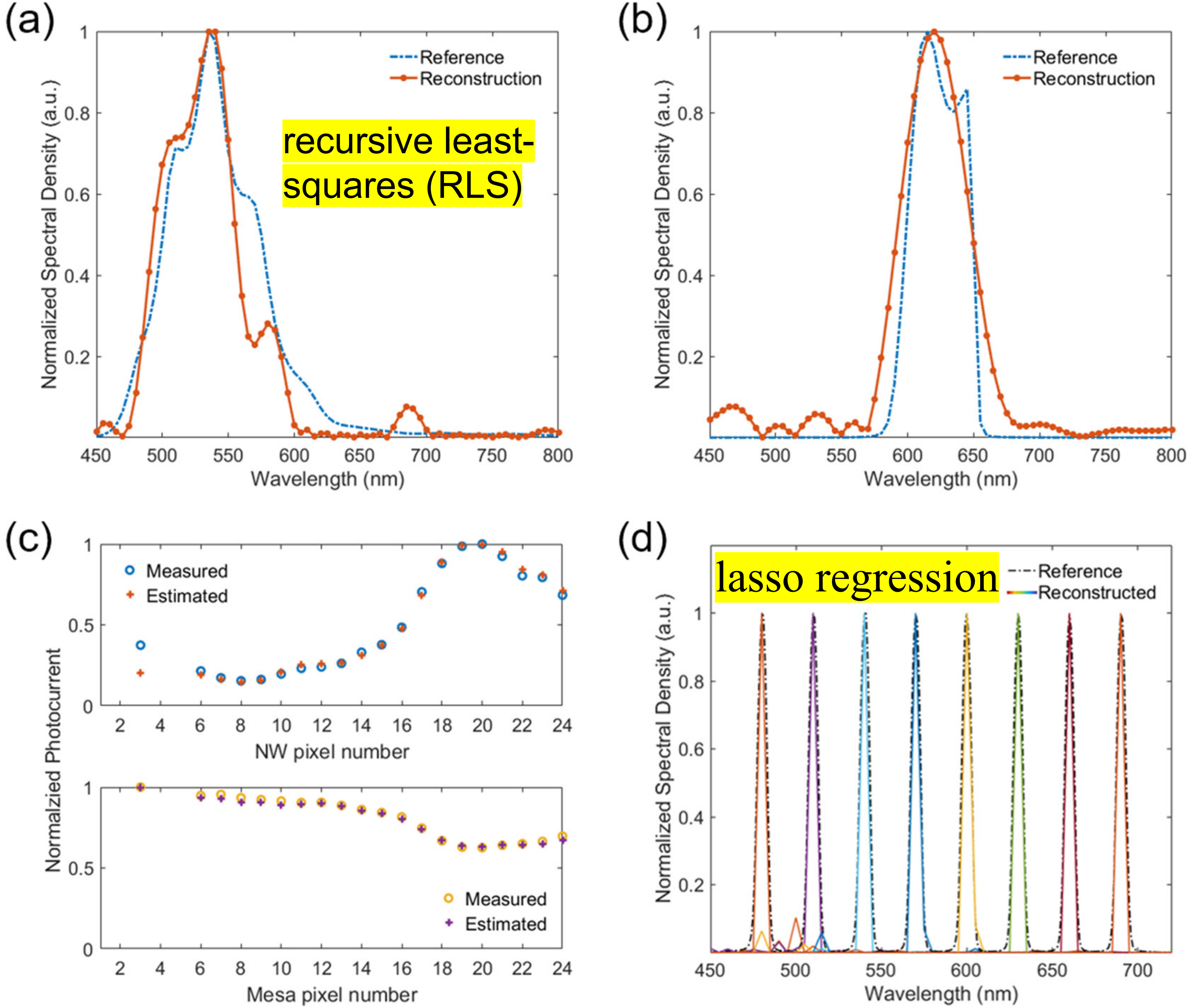
$$I_k = \int_{\lambda_1}^{\lambda_2} R_k(\lambda)P(\lambda) + n_k(\lambda)\mathrm{d}\lambda, \quad k = 1, 2, ..., N$$

where $P(\lambda)$ is input spectrum, I_k is the photocurrent of photodetector k, R_k is the responsivity spectrum of photodetector k, and n_k is the measurement noise. N is the number of photodetectors. λ_1 and λ_2 are the bounds of the spectrum. After discretization, eq 1 can be expressed in vector form as follow

$$I_k = \mathbf{R}_{\mathbf{k}}^{T}[\lambda]\mathbf{P}[\lambda] + n_k, \quad k = 1, 2, ..., N$$

where $\boldsymbol{R_k}^{\boldsymbol{T}}[\lambda]$, $\boldsymbol{P}[\lambda]$ are the row and column vector forms of R_k and P_k.

DOI: (10.1021/acs.nanolett.9b03862)



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