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Improving the efficiency of electron holography by combining off-axis and in-line holography

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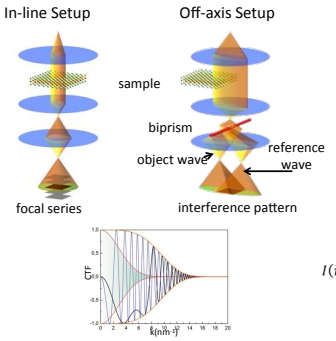
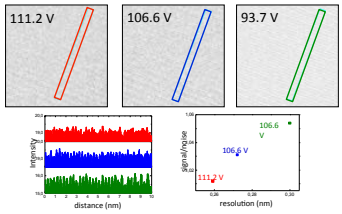
Motivation





$$I(\vec{r},\Delta f) = |FT^{-1}[\Psi_0(\vec{q})\exp(-i\chi(q)]|^2 \otimes FT^{-1}[E_S(\Delta f,\alpha,q)]$$

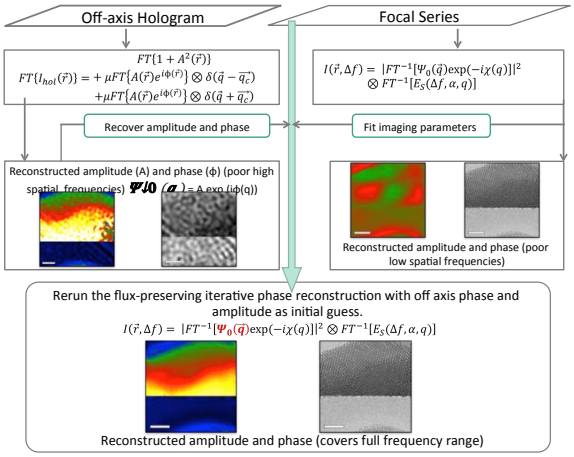
$$\chi(q) = \pi\lambda\Delta f q^2 + 0.5\pi\lambda^3 C_S q^4$$ Contrast transfer function

$$E_S(\Delta f,\alpha,q) = \exp[-(\pi\alpha\Delta f q)^2]$$ Spatial coherence envelope

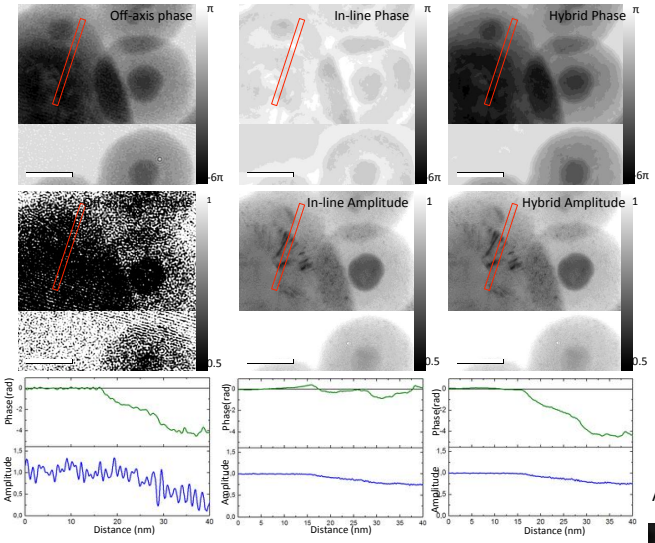
○ In-line electron holography (IH) is very efficient for high spatial frequencies but performs poorly in the low spatial frequency regime.

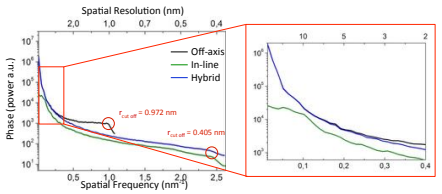
○ Off-axis electron holography equally covers all spatial frequencies but is less efficient than IH at high spatial frequencies due to low signal to noise ratio.

Method



Results

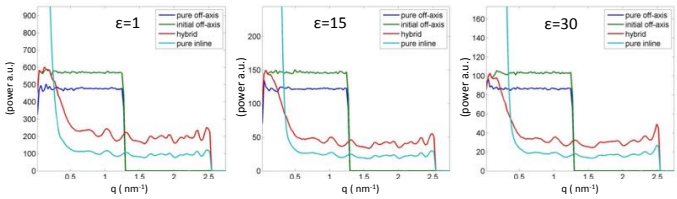




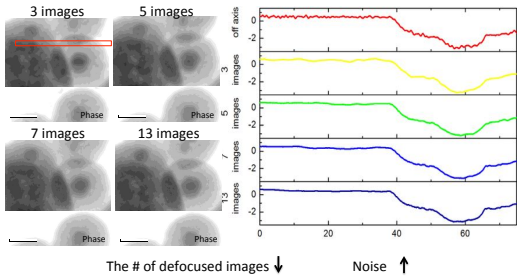
Power spectrum analysis shows hybrid electron holography;

- Higher information transfer than in-line at low spatial frequencies.
- Much higher cut-off resolution than off-axis.
- Higher information contrast than in-line and off-axis at all spatial frequencies.

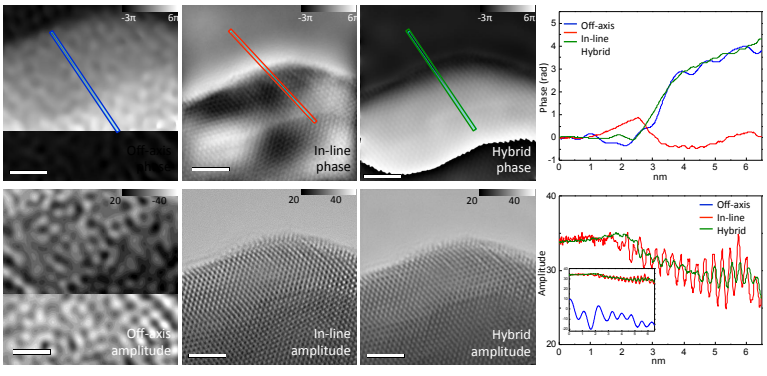
Illumination condition



The effect of number of defocused images that were feed to reconstruction



Au nano-particles (atomic resolution)



Summary

	Off-axis Holography	In-line Holography	Hybrid Holography
Number of images	1	at least 3	at least 4
Reconstruction	+	-	slower
Efficiency (reconstructed pixel)	-	-	+
Required coherence	-	+	low
Microscope alignment	-	+	standard
Sample drift and mechanical stability sensitivity	-	+	low
Sample requirements	-	+	near edge
Experimental requirements	-	o	biprism + energy filter
Quantitativeness	+	-	**quantitative**
Phase sensitivity	-	+	**high**
Achievable resolution	-	+	**information limit**
Ideal for what bandwidth	low spatial frequencies	high spatial frequencies	**full range of spatial frequencies**

References

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3. Twitchett, A. C.; Dunin-Borkowski, R. E.; Midgley, P. A., *Philosophical Magazine* **86**, 5805-5823.,2006.
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