1 Optics

I want a Didinium ($0.1 \times 0.1\text{mm}^2$) to span 3×3 pixels.

pixel size = $1.55\mu\text{m}$.

Magnification (Negative for real images, because they are inverted)

$$M = -\frac{3 \times \text{Pixel size}}{\text{Didinium size}} = -0.0465 \approx -0.05. \tag{1}$$

Focal length

$$M = \frac{f}{f - \text{WD}} \implies f = \text{WD}\frac{M}{M-1} = \text{WD} \times 0.0476... \approx \text{WD} \times 0.05. \tag{2}$$

Working Distance: Paper has WD = $60 - 100$mm.

Things to consider: vibrations from the pump, having space to add filters etc

Things to ignore: Depth of view, blurriness is not a problem for tracking. Distortion, can be corrected digitally.

Minimal Field of View:

$$FOV() = \arctan\left(\frac{h_o/2}{\text{WD}}\right) \tag{3}$$

Following table shows Working Distance, required focal length and minimal field of view.

WD (mm)	f (mm)	FOV (°)
50	2.5	45
100	5	14
200	10	7
300	15	5

To image just $5 \times 5\text{mm}^2$, $M = -0.5$. Then $f = \text{WD} \times 0.33... = \text{WD}/3$

WD (mm)	f (mm)	FOV (°)
50	17	3
100	33	1.4
200	67	0.7
300	100	0.5