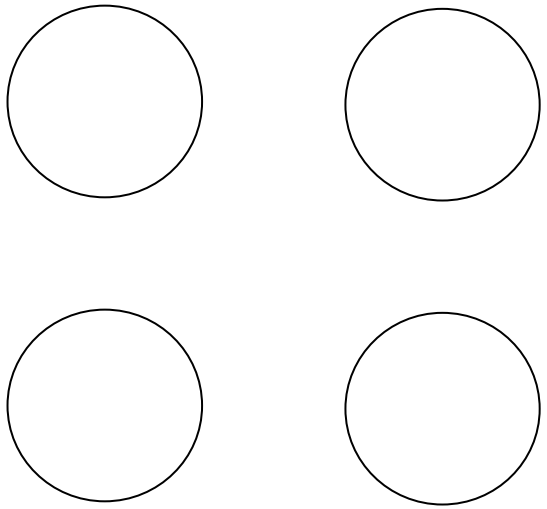
“Dots on the Fly”

Concept:

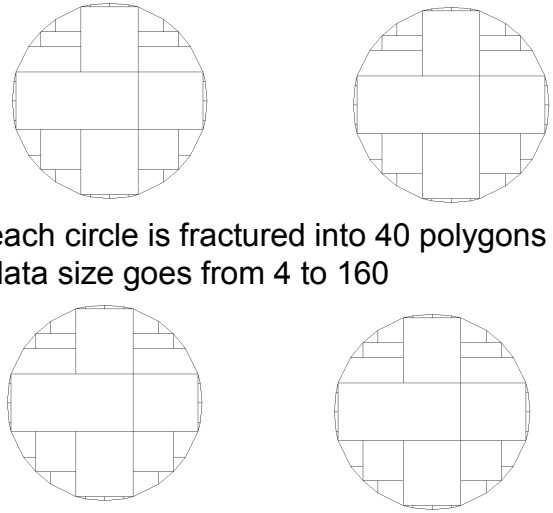
- electron beam lithography can be a slow process due to serial exposure of patterns, compared to photolithography which is a blanket exposure process
- some applications desire large (e.g. 1 cm^2 or greater) arrays of nanometer sized dots (e.g < 20 nm) at nanometer sized pitch (e.g. < 100 nm). note that a 1 cm^2 array at 100 nm pitch contains 1E10 dots!
- normally one would create a CAD file containing dots/circles at the desired diameter and pitch to then create the pattern in resist by EBL. however, dots/circles must be “fractured” into separate polygons which approximate the original shape. this is necessary because the hardware works in cartesian and not polar coordinates
- this fracturing into polygons increases the total number of shapes in the CAD file. there is some hardware delay in writing each shape and can cause the write time to be excessively long for large arrays of dots
- *“dots on the fly” method of writing aims to produce the same final pattern in resist, but using significantly fewer shapes in the CAD file, and thus a shorter overall write time*

Data Fracture: Circles vs. Squares

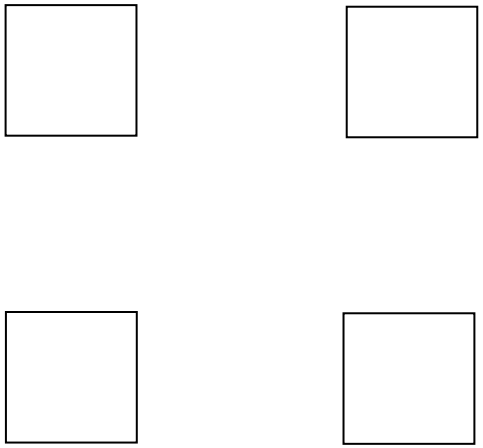


circles

fracture

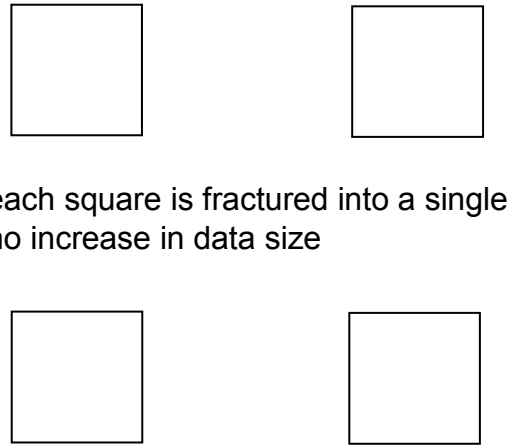


each circle is fractured into 40 polygons
data size goes from 4 to 160



squares

fracture



each square is fractured into a single square
no increase in data size

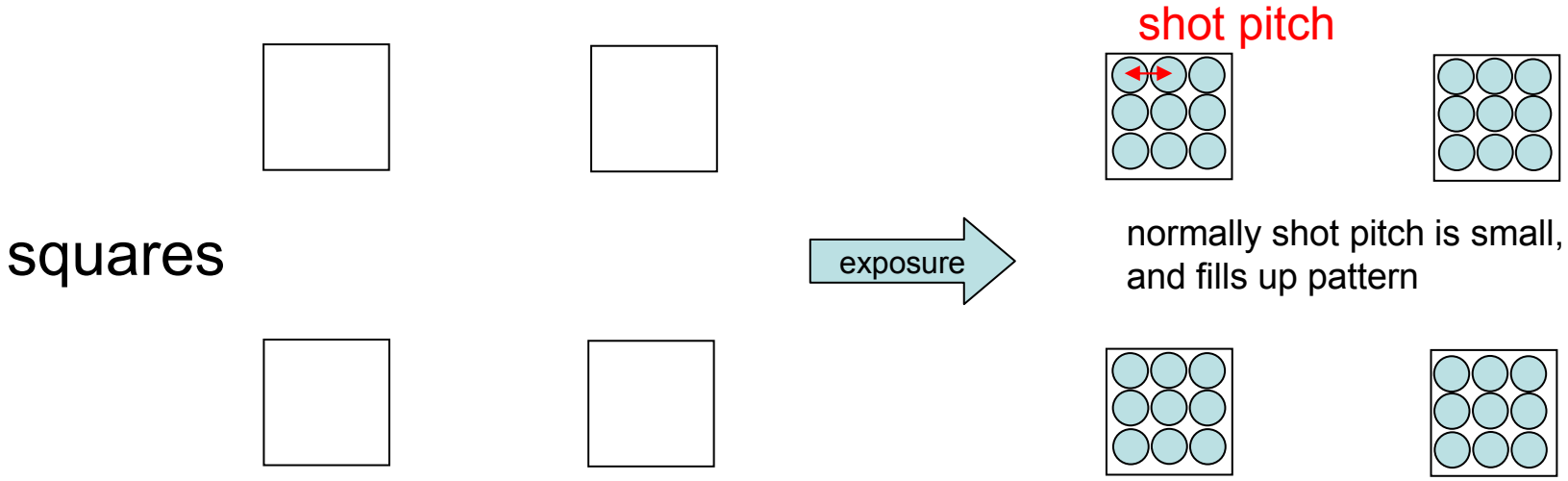
Dots on the Fly

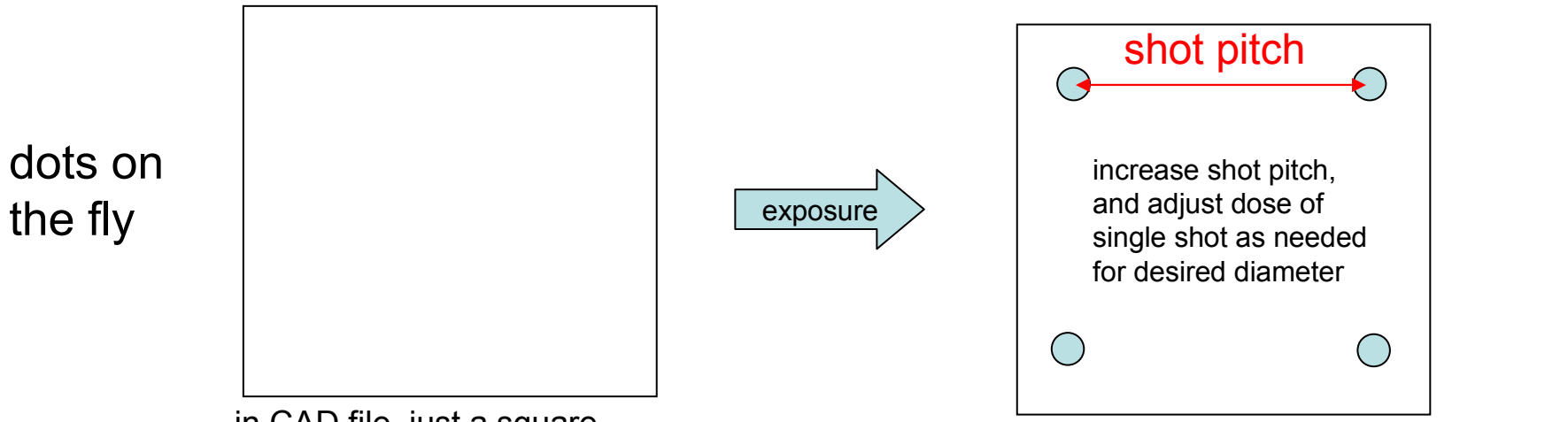
- the previous slide demonstrates how fracture shapes can dramatically increase for circles/dots

- this can be reduced by using squares instead of circles. the squares can “turn into” circles in the exposure process by making the squares smaller than the desired dot size and overexposing them so that the corners round out and it effectively becomes a dot.

- however, even with squares, there are still a lot of objects in the CAD file. with “dots on the fly method” the number of objects can be further significantly reduced

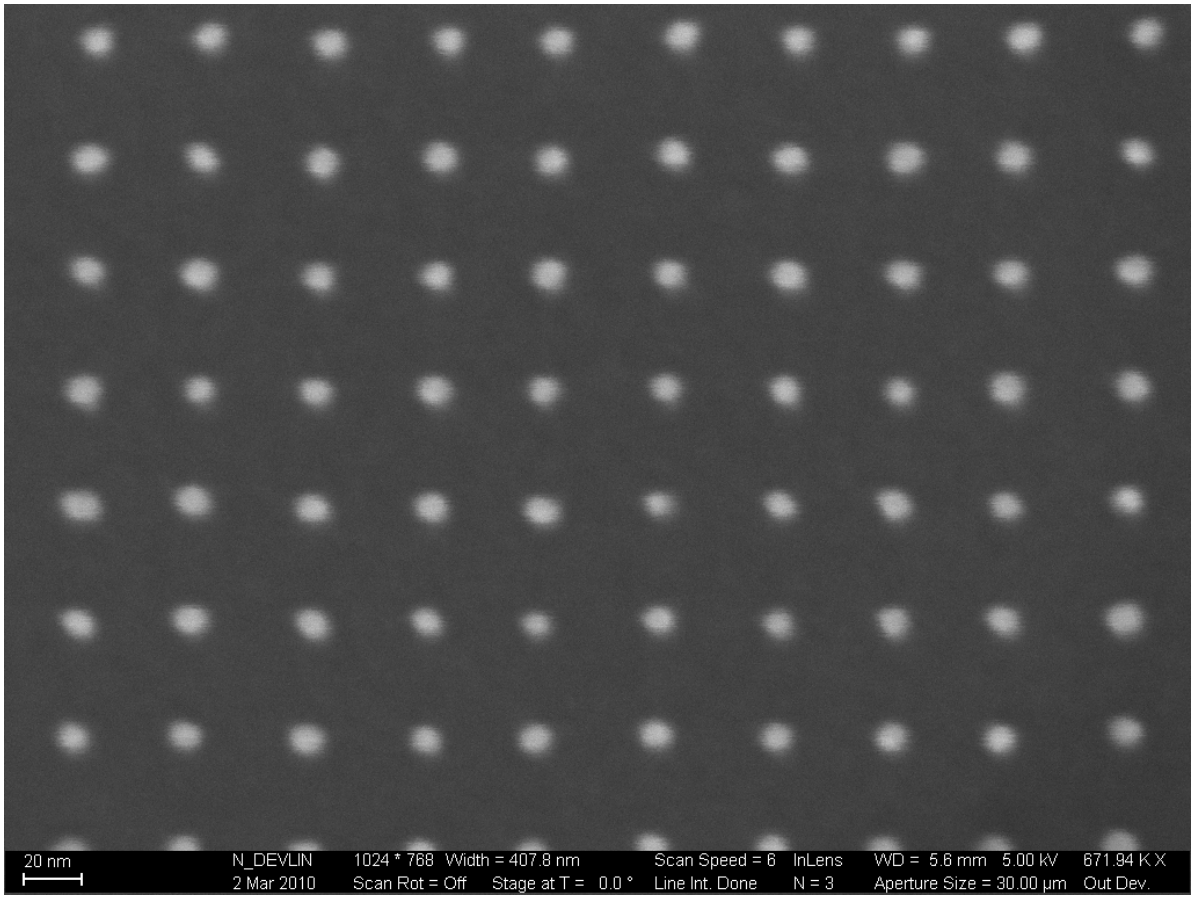
Data Fracture: Squares vs. Dots on the Fly





in this case the dots on fly method, has 1 CAD object while squares has 4 CAD objects. ***so hardware time delay per object is reduced by 4X.***

Dots on the Fly example result



10 nm dots on 40 nm pitch

Process Flow for previous slide

- spin coat
  - 4” diameter silicon wafer
  - 1% HSQ, 5000 RPM, 2500 RPM/sec, 60 sec
  - hot plate bake, 80 C, 4 min
  - resulting thickness = 11.6 nm
- exposure
  - beam current = 600 pA, 100 kV
  - shot pitch = 40 nm
  - specified dose = 510 uC/cm2
  - equivalent dose = 5000 uC/cm2
- develop
  - 70 sec immersion in MF-319 (2.3% TMAH)
  - DI water rinse