

How to Print From PDF to Geology Lab Plotters

These are step-by-step instructions with images showing what the settings should look like.

1. Open your PDF File

The screenshot displays the Adobe Acrobat Pro interface with a PDF document open. The document title is "FLUORINE-ETCHED NANOSTRUCTURES FOR ENERGY STORAGE APPLICATIONS" by M. Feldman, H. Gullapalli, A. L.M. Reddy, R. Vajtai, P. M. Ajayan. The document is divided into several sections:

- Abstract:** Graphene has been the focus of much current research, due to its interesting electrical and structural properties for electronics applications. Here we show that fluorine can be introduced during graphene growth on stainless steel (SS) substrates to simultaneously create useful nanostructures, using the chemical vapor deposition (CVD) technique. These structures are geometrically optimal for reversible ion intercalation, where the graphene acts as an electrode and the SS is a current collector. Direct growth of graphene on electrode materials makes this process very scalable and cost-effective method for developing thin-film energy storage devices.
- Introduction:** Since the two-dimensional carbon structure, known as graphene, was discovered in 2004, it has been a very promising material for various applications such as solar cells, sensors, transistors, inert coatings, etc. Figure 1 shows the configuration of the honeycomb lattice illustrating graphene's ability to form buckyballs, carbon nanotubes, and Graphite. Graphene can be a useful battery electrode due to its superior electrical conductivity, high surface area and a broad electrochemical window. Originally, exfoliated graphene coated on to conducting electrodes resulted in poor adhesion and electrical contact. Chemical vapor deposition (CVD) allows graphene to be grown directly on substrates.
- Experimental Methods:** Figure 2 shows a schematic of optimized growth process: (1) Anneal, 30 minute heating cycle; (2) Annealing time and 2 minute; At flush; (3) 10 minute exposure to organic compound and fluorine etch; (4) 2°C cooling rate while exposed to organic compound; (5) C diffusion under gradual cooling. The steps are: 1. Create SS discs with constant diameter for coin-cells; 2. Etch nanostructures on to the substrate using fluorine-based organic vapors; 3. Allow carbon diffusion of carbon as SS cools to produce graphene; 4. Analyze under scanning electron microscope (SEM) and Raman Spectroscopy; 5. Load sample in device and obtain charge/discharge profile.
- Results:** Figure 3 shows SEM images of SS (A) before CVD growth, (B) after growth with organic vapor, and (C) after growth with fluorinated organic vapor. (D) Image of the surface of fluorinated sample from an angle. (E) View of single pore prepared in graphene. (F) Inverse view of porous substrate to reveal cylindrical structure of pores. Figure 4 shows Raman spectra of the graphene grown directly on stainless steel using hexane and a fluorinated organic compound, with peaks labeled for Hexase and Fluoro-carbon.
- Charge-discharge voltage profile:** Figure 5 shows a graph of Voltage (V vs. Li/Li+) vs. Time (hr) for cycles between 3.2 V and 0.02 V vs Li/Li+ at a current rate of 5µA/cm² in an electrolyte of LPF₆ in mixture of ethylene carbonate (EC) and dimethyl carbonate (DMC). The graph shows three distinct peaks in voltage over time.
- Summary:** Scalable method for growth of graphene layers and useful nanostructures on SS substrates with CVD; Good electrochemical properties and stability over Li-ion charge/discharge cycles makes this a promising step towards better electrode materials.
- Future Work:** Further optimize the growth parameters; More systematic battery testing on a variety of SS samples; Growth on similar metallic substrates (copper, nickel, etc.); Optimization of growth to create new controlled structures.
- References:** [1] X. Li et al., Science 2009, 324, 1312; E. S. Kim et al., Nature 2009, 457, 706; [2] A.C. Ferrari et al., Phys. Rev. Lett. 2006, 97, 17; [3] Zhang et al., ACS Nano 2009, 3, 907; [4] R. Gullapalli et al., Small 2011, 7, No. 12, 1897-1799; [5] A.L.M. Reddy et al., ACS Nano 2010, 4(11), 6337-6342.

The document also features logos for Rice University, NIST, NanoJapan, and UF University of Florida. The footer indicates the material is based on open work supported by the National Science Foundation's Partnerships for International Research & Education Program (CISE-096407).

2. Under View, Select Zoom → To Actual Size

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Zoom

- Zoom To... Ctrl+Y
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- Dynamic Zoom
- Actual Size Ctrl+1**
- Zoom to Page Level Ctrl+0
- Fit Width Ctrl+2
- Fit Height
- Fit Visible Ctrl+3
- Pan & Zoom
- Loupe Tool
- Refresh Ctrl+4

Click on Tools, Comment and Share to access additional features.

DESIGNED NANOSTRUCTURES FOR ENERGY STORAGE APPLICATIONS

K. S. Han, A. L. M. Reddy, R. Vajtai, P. M. Ajayan

Department of Mechanical Engineering and Materials Science, Rice University, Houston, TX

that fluorine can be introduced during the growth of graphene on SS substrates to simultaneously create useful nanostructures, using the chemical vapor deposition (CVD) technique. These structures are geometrically optimal for reversible ion intercalation, where the graphene acts as an electrode and the SS is a current collector. Direct growth of graphene on electrode materials makes this process very scalable and cost-effective method for developing thin-film energy storage devices.

Introduction

Since the two-dimensional carbon structure, known as graphene, was discovered in 2004, it has been a very promising material for various applications such as solar cells, sensors, transistors, inert coatings, etc.

Figure 1: Changing the configuration of the honeycomb lattice illustrates graphene's ability to form buckyballs, carbon nanotubes, and graphene.

Graphene can be a useful battery electrode due to its superior electrical conductivity, high surface area and a broad electrochemical window. Originally, exfoliated graphene coated on to conducting electrodes resulted in poor adhesion and electrical contact. Chemical vapor deposition (CVD) allows graphene to be grown directly on substrates.

Experimental Methods

Figure 2: Schematic of optimized growth process: (1) Ar/H₂ 30 minute heating cycle, (2) Annealing time and 2 minutes Ar flush, (3) 10 minute exposure to organic compound and fluorine, (4) 2°C/s cooling rate while exposed to organic compound, (5) C diffusion under gradual cooling.

- Create SS discs with constant diameter for coin-cells
- Etch nanostructures on to the substrate using fluorine-based organic vapors
- Allow carbon diffusion of carbon as SS cools to produce graphene
- Analyze under scanning electron microscope (SEM) and Raman Spectroscopy
- Load sample in device and obtain charge/discharge profile

Results

Figure 3: Broad SEM images of SS (A) before CVD growth, (B) after growth with organic vapor, and (C) after growth with fluorinated organic vapor. (D) Image of the surface of fluorinated sample from an angle. (E) View of single pore disk in graphene. (F) Inside view of broken substrate to reveal cylindrical structure of pores.

Figure 4: Raman spectra of the graphene grown directly on stainless steel using hexane and a fluorinated organic compound.

Figure 5: Charge-discharge voltage profile of cycles between 3.2 V and 0.02 V vs. Li/Li⁺ at a current rate of 50 A/cm² in an electrolyte of LiPF₆ in mixture of ethylene carbonate (EC) and dimethyl carbonate (DMC).

Summary

- Scalable method for growth of graphene layers and useful nanostructures on SS substrates with CVD
- Good electrochemical properties and stability over Li-ion charge/discharge cycles makes this a promising step towards better electrode materials

Future Work

- Further optimize the growth parameters
- More systematic battery testing on a variety of SS samples
- Growth on similar metallic substrates (copper, nickel, etc.)
- Optimization of growth to create new controlled structures

References

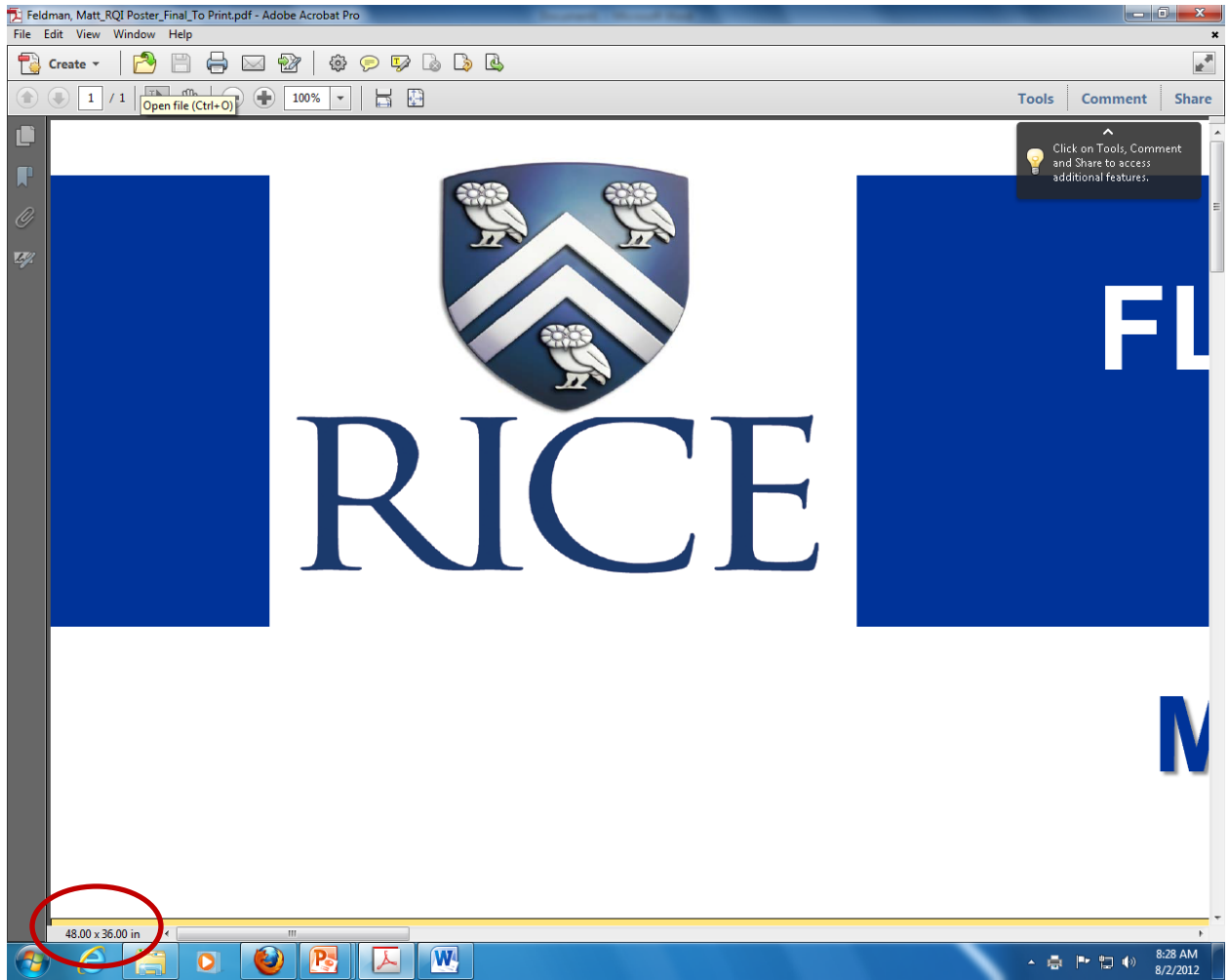
- X. Li et al., Science 2008, 324, 1313; S.S. Kim et al., Nature 2009, 457, 706
- A.C. Ferrari et al., Phys. Rev. Lett. 2006, 97; D. Wang et al., ACS Nano 2009, 3, 907
- R. Colquhoun et al., Small 2011, 7, no. 12, 1697-1709
- A.L.M. Reddy et al., ACS Nano 2010, 4 (11), 6337-6342

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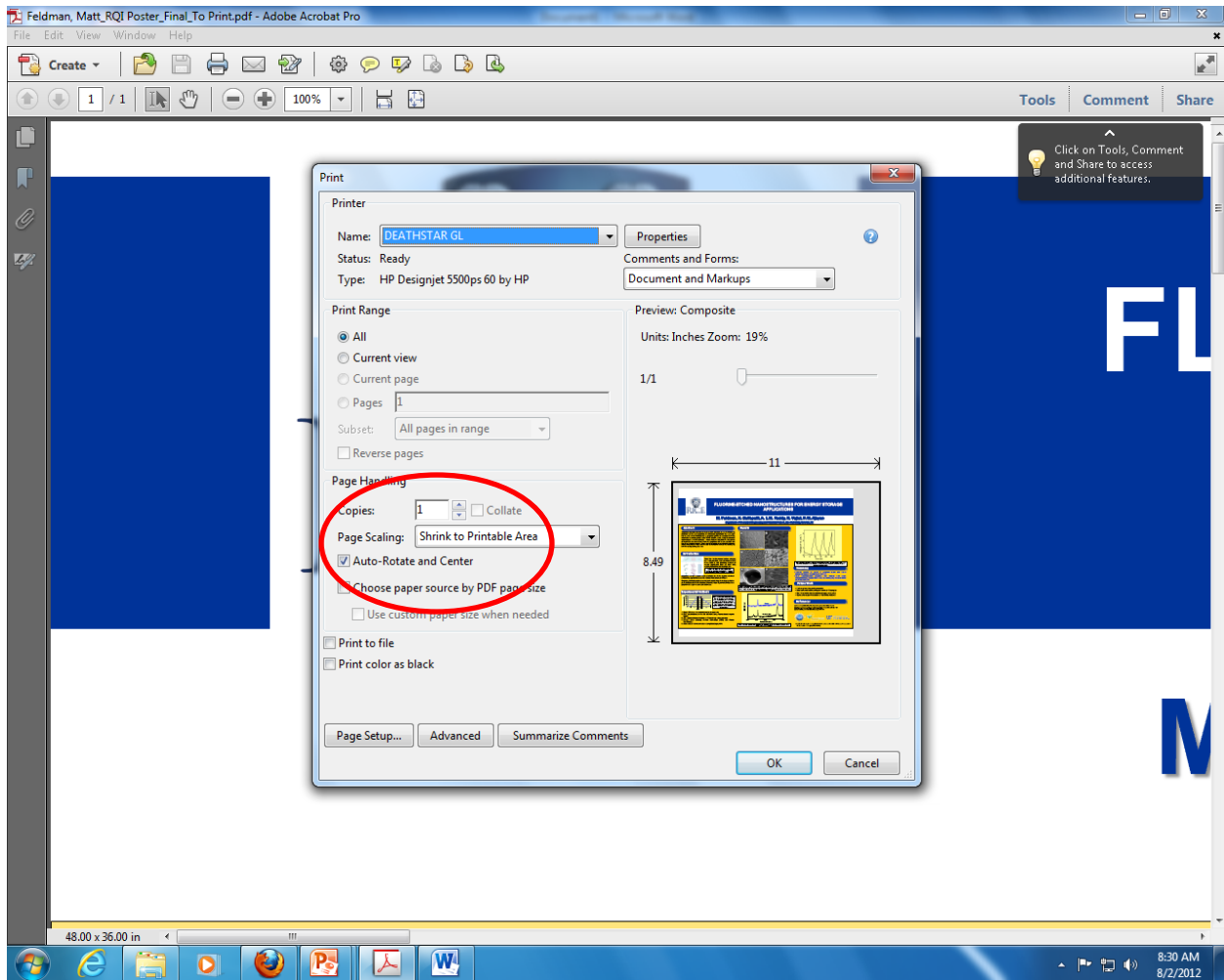
This material is based upon work supported by the National Science Foundation's Partnerships for International Research & Education Program (CISE-0969407)

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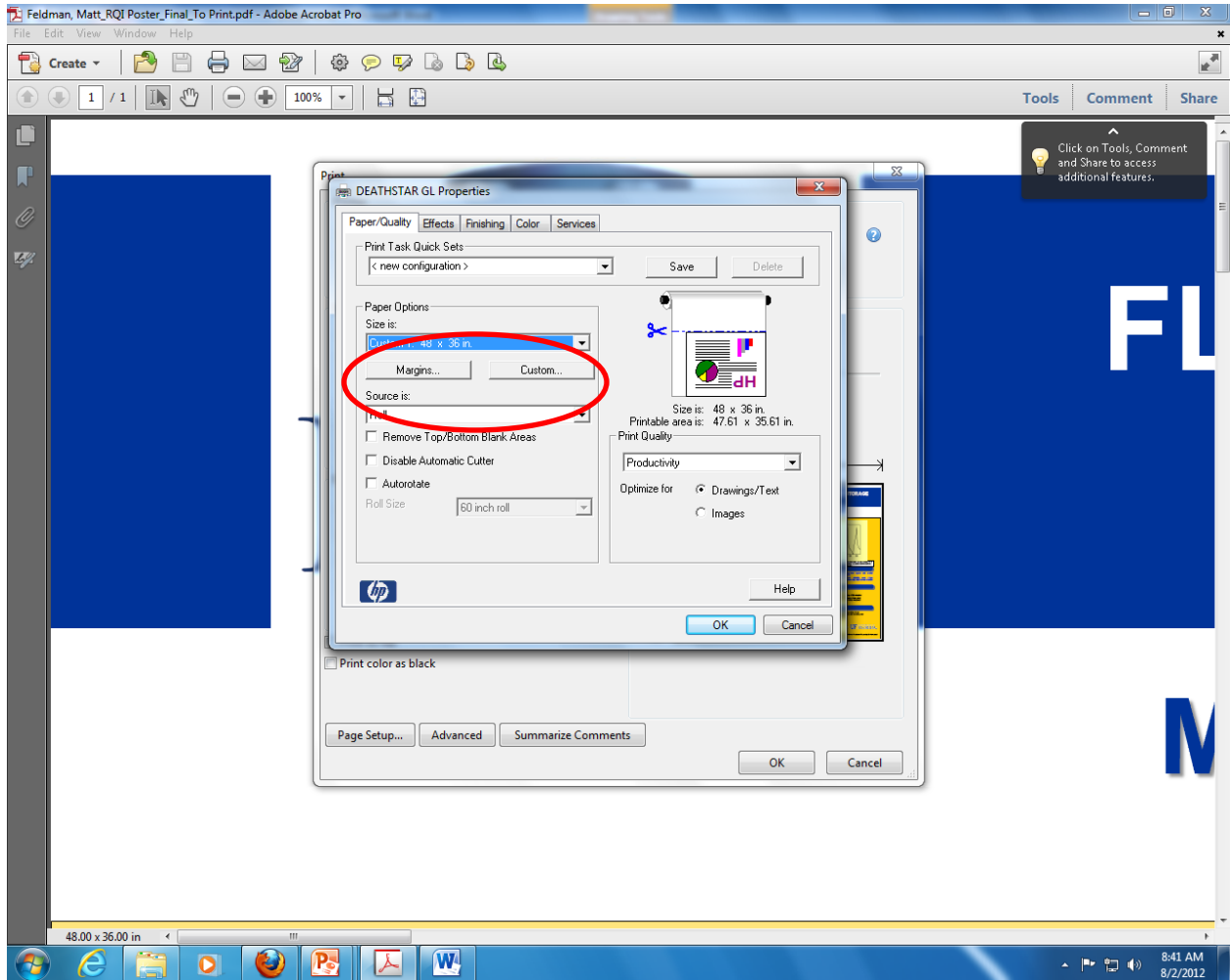
3. In the bottom left you will now see the actual size of your poster. Write this down or remember it.



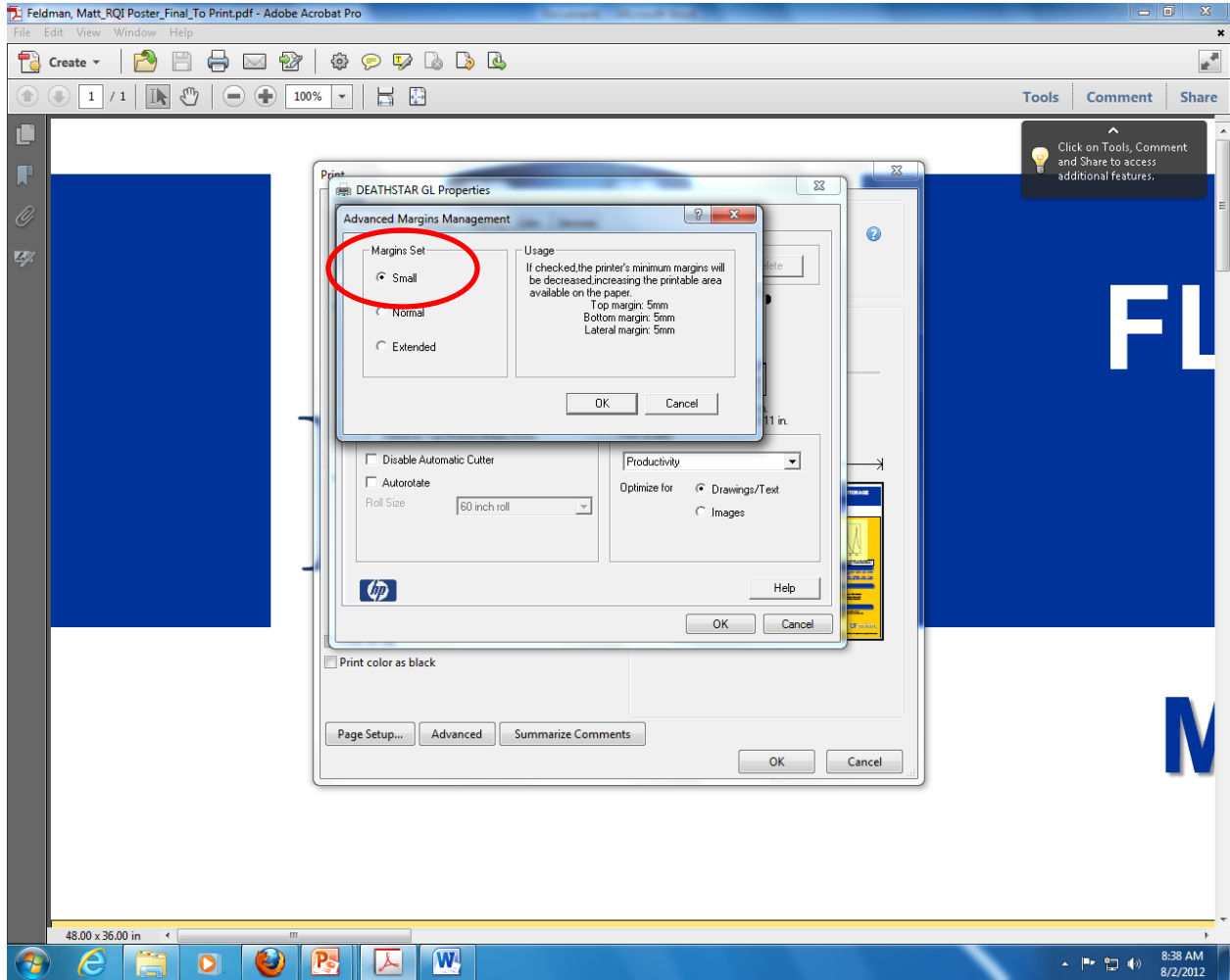
4. Now select File → Print to bring up the Print Screen window. Be sure that the plotter you want to use is selected. If printing from a PDF you should ONLY use the 'GL' names. Be 100% sure that the plotter you want to use is selected now or the properties won't set correctly in the next steps.
 - a. Choose your plotter based on the available paper roll sizes and the type of ink you want. UV ink and glossy paper look nicest and will last much longer but it takes longer to dry and you risk smudging it. Plain coated paper and regular ink is better for a poster you will only use once or twice. The ink will fade if displayed for an extended period of time.
 - b. Make sure that 'Shrink to Printable Area' is selected under Page Scaling
 - c. Make sure that the 'Auto Rotate and Center' box is checked



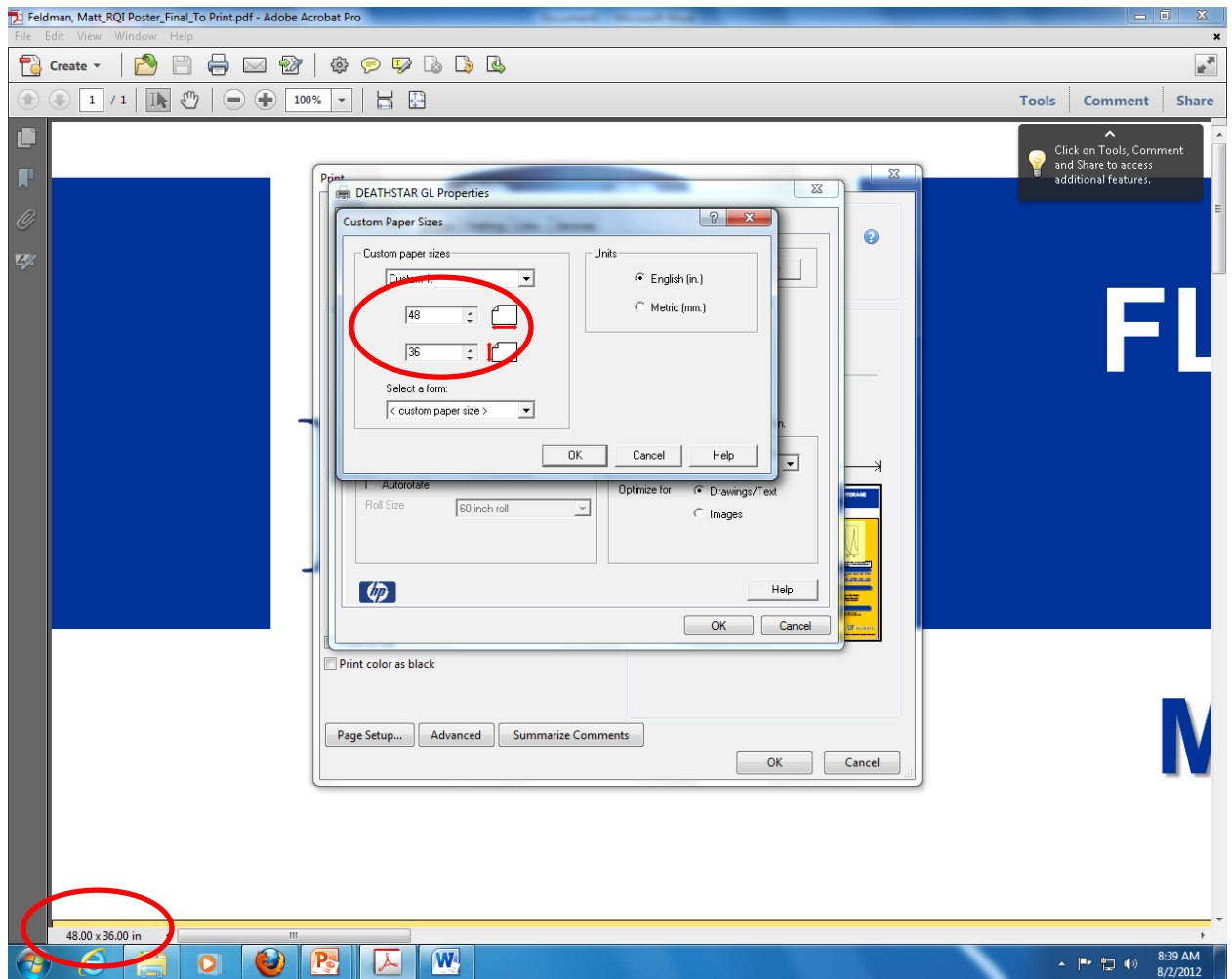
- Now open the properties setting. Your screen should now look like this. You will be opening the 'Margins' and 'Custom' tabs on this screen to set the correct printing size.



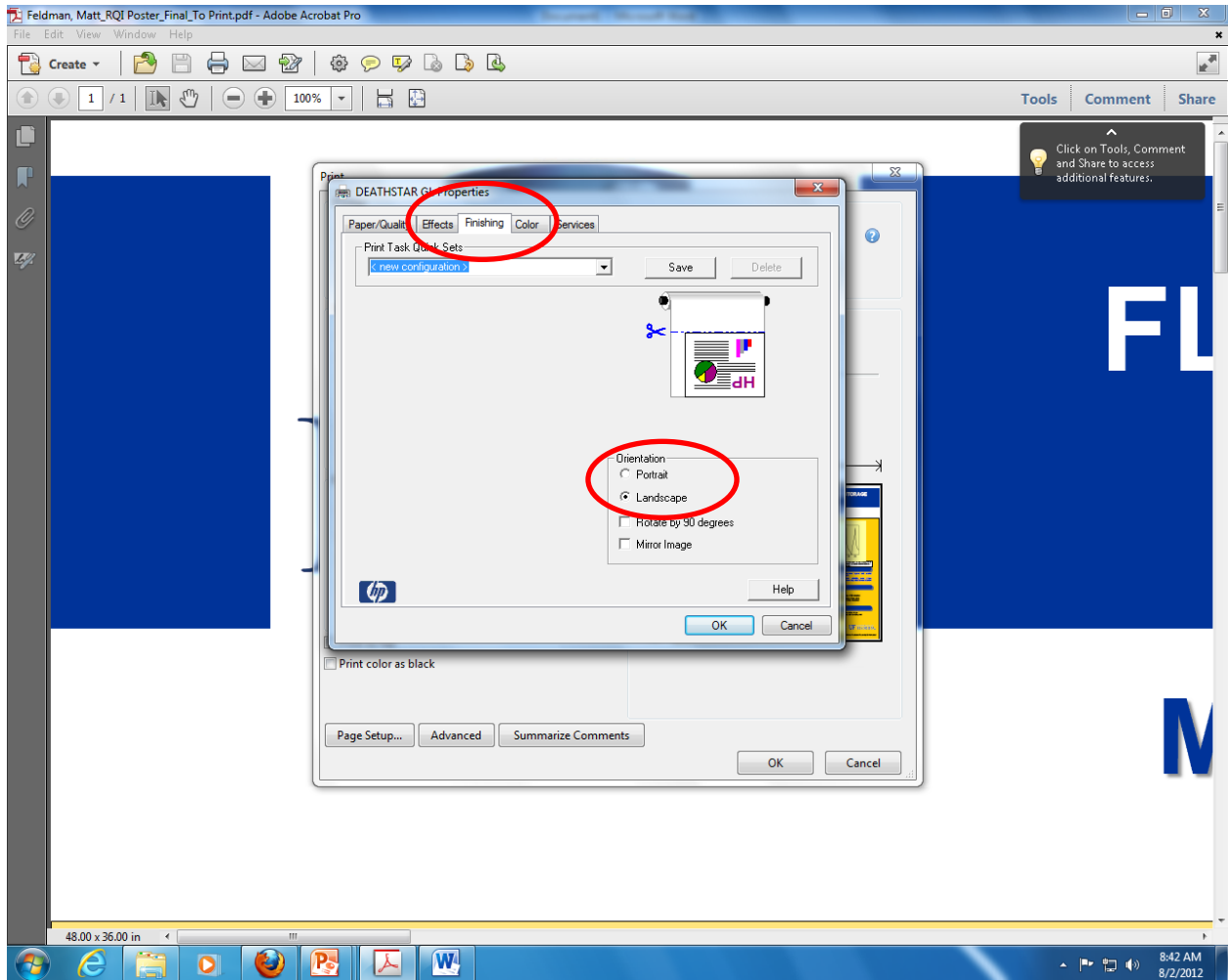
6. Under the 'Margins' tab select 'Small' and then 'OK'



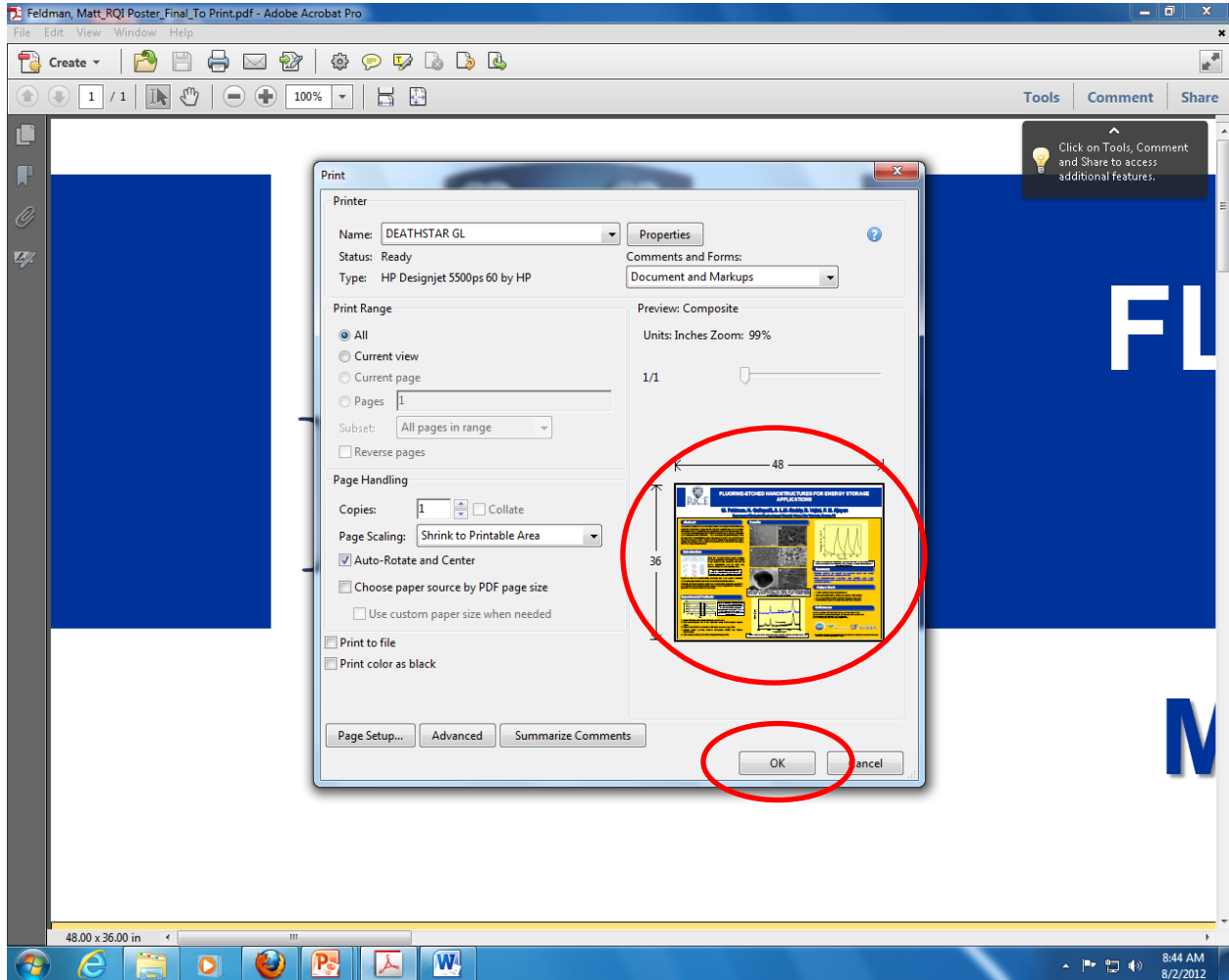
- Under the 'Custom' tab you will need to enter in your exact poster dimensions. If you forgot to write them down you should still be able to see them in the bottom left corner. Then click on 'OK'.



- Now you need to set the printing orientation. Click on the 'Finishing' tab and select the orientation that makes best use of the orientation. The preview will change to let you see how much of the paper is used based on which orientation you select. Then click 'OK'.



9. Review the preview pane to make sure your poster is displaying properly and the orientation is set correctly. You are now back to the main print screen and are ready to send your poster to the printer by clicking 'OK'. If for some reason it does not print properly go back through these steps to double check your settings and/or try the other orientation.



Happy Printing!!!!

