Technology For Plagiarism Detection

International Workshop on Accountability in Science and Research Funding

June 24, 2011

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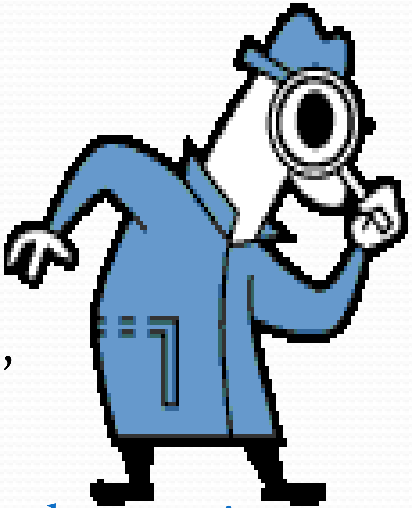
Director, Administrative Investigations
Office of Inspector General
National Science Foundation

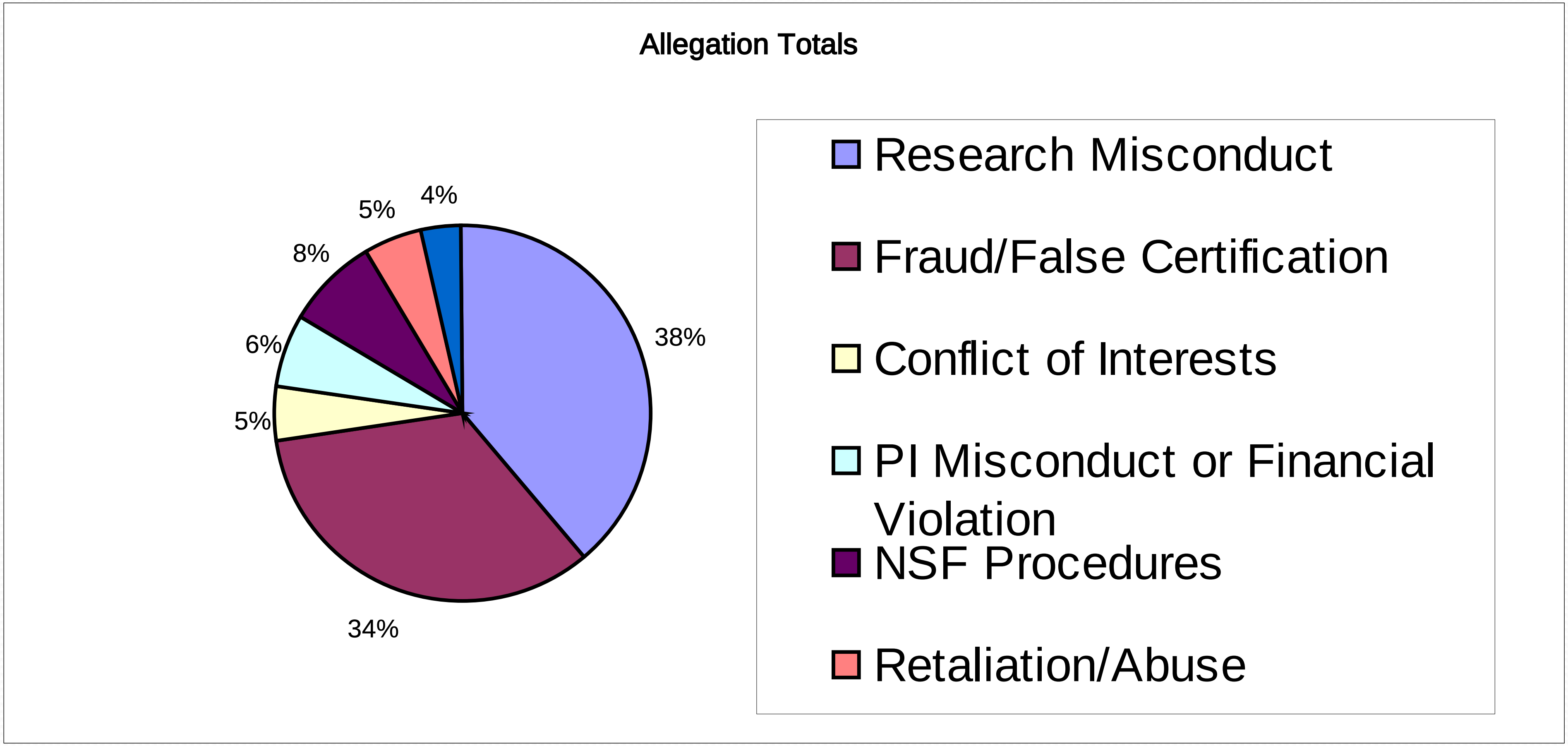
Who We Are

- **Offices of Inspector General**
  - Prevent and detect fraud, waste, abuse
  - Promote economy, efficiency, effectiveness
  - Conduct investigations, audits, inspections, reviews of agency programs (funded activities), operations
- **Features:**
  - Independent of agency management
  - Jurisdiction (NSF activities, programs, operations)
  - Staff of experts: administrators, attorneys, auditors, criminal investigators, and scientists



Responsible for ensuring the integrity in NSF's programs and operations

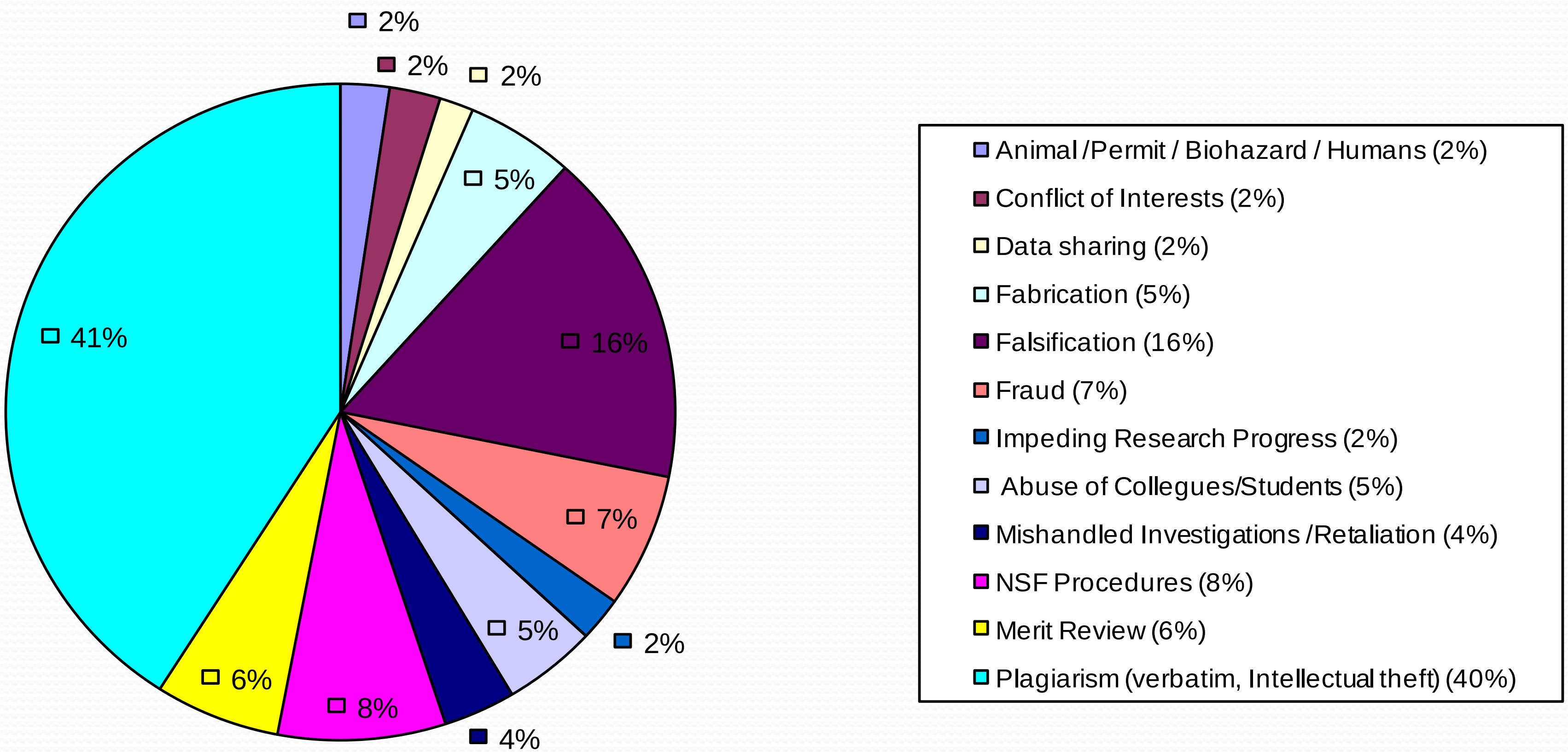
Snapshot of Allegations
Office of Investigations



What is Research Misconduct (RM)?

- Federal-wide definition and procedural framework (Dec. 2000).
- RM means fabrication, falsification, or plagiarism in proposing or performing research [], reviewing research proposals [] or in reporting research funded by [the agency]. 45 C.F.R. 689.1.a
- Not honest error or differences of opinion.
- Must be reckless, knowing, or intentional and not careless.
- Must be "a significant departure form the accepted practices of the relevant research community."
- NSF RM Regulation delegates investigation to NSF/OIG

Common Types of Administrative Allegations



Research Misconduct Findings:

Fabrication	12%	Falsification	15%
Plagiarism	66%	Other	11%

Ensuring appropriate credit to avoid plagiarism

(Q) C R

Quotation

Citation

Reference

Research Misconduct Process

- Inquiry – Confidential between IG and subject
- Referral of Investigation to Institution
- OIG Investigation
- Report to Agency - Subject Comments
- Agency Decision
- Appeal

A few of our favorite excuses

Why did these plagiarism excuses not work?

- My graduate student / post doc / lab manager / etc. wrote that part and I assumed they knew how to cite.
- It's only background material.
- The reviewer's are smart enough to know what is mine and what is in the literature.
- I used the same words, but I meant something different.
- I was told that having between 70-80 citations in a proposal was enough. Anymore and I would look like I wasn't proposing to do something new.
- My computer was attacked by a virus and the ensuing confusion, combined with my influenza, caused me to inadvertently upload the incorrect version.
- I was distracted by bird vocalizations outside my thatched roof hut, grabbed my digital camera … , and when I returned to my computer where I thought I had saved my changes to the material, it had crashed with the wrong draft saved.

Plagiarism Case Study 1

- PI submitted SBIR-1 proposal as follow up to his MS Students thesis work ($100K, 6 months).
- PI copied the thesis into his final report and proposal for the SBIR-2 award ($500K).
- University notifies OIG of plagiarism allegation
- When awarded, PI used the money to pay his child's tuition at a University, along with other personal expenses.
- PI denied everything. His wife did not.

Plagiarism Case Study 1

- At a meeting with DOJ, the professor through his attorneys indicated that he would like to
  1) plead guilty to a criminal count (1001) and pay $240,000 restitution and fines
  2) avoid jail
  3) avoid Federal action against his wife

- NSF OIG recommended RM finding and debarment.

  Professor and NSF settled for 3 years voluntary exclusion from Federal funding.

Plagiarism Case Study 2

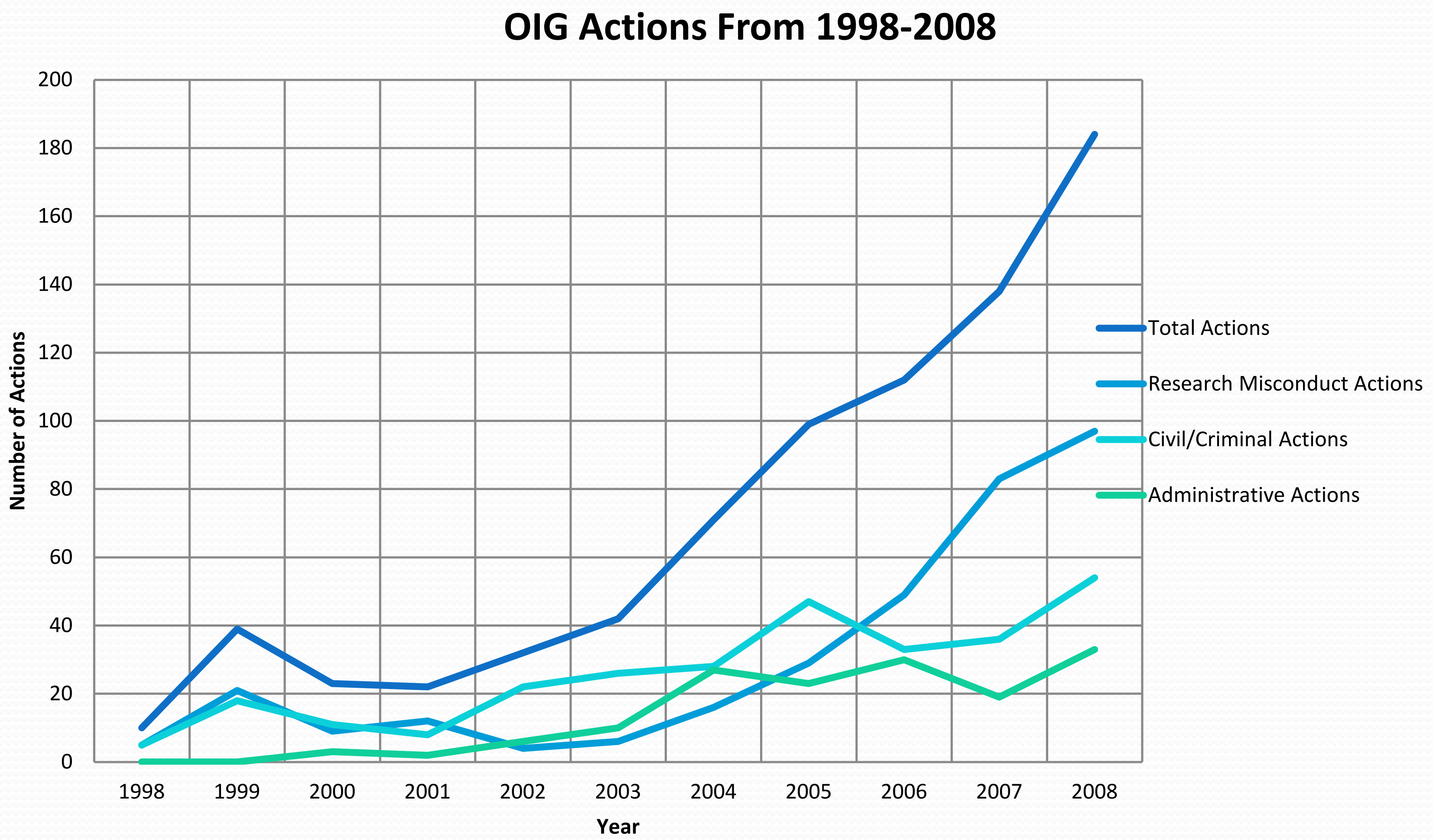
- US researcher serves as peer reviewer for European Agency
  - Keeps proposal / uses 2 pages of material for his next NSF proposal
  - European authors selected to peer review his proposal
  - OIG works with funding agency to get original document

- Copied text includes novel research idea never discussed before
  - NSF concludes subject committed verbatim and intellectual theft
  - Debars subject for two years
  - Subject is "soft" money; has to seek employment

Plagiarism Case Study 3

- Research submits proposal with text copied from multiple sources
  - Subject admits mistake and "notifies" all source authors
  - Notifications less than detailed
  - OIG Recommends 3 yrs certifications/assurances
- NSF DD asks us to interview author of a source proposal
  - Researcher confirms that he gave proposal to subject
  - Stated he could use it for guidance; not verbatim; was hoping for a collaboration
- NSF DD makes finding and debars subject for 1 year based on verbatim and intellectual theft

Trends


OIG Actions From 1998-2008
200
180
160
140
120
100
80
60
40
20
0
Number of Actions
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year
Total Actions
Research Misconduct Actions
Civil/Criminal Actions
Administrative Actions

Technology and Identifying Plagiarism

- Apparent shift of plagiarism technique from using single to multiple sources
  - Pre - 2000: Plagiarism often characterized by large blocks of text, figures from one or only few sources
  - Currently: Plagiarism of single sentences adding up to mlareger blocks of text drawn from multiple sources (mosaic or patchwork plagiarism)
    - 1 proposal with text and figures from 24 sources
    - 6 proposals with text and figures from 56 sources

Technology and Identifying Plagiarism

- Investigative analysis must consider the block of text as well as individual sentences
- Many more internet sources
- Electronic software detection makes finding evidence of a pattern in publications, theses, other proposals easier to find
- Two types of software needed to facilitate hand analysis
  - Software to scan internet/publications for common text
  - Software to compare two documents for similarities

Current Technologies

- Internet Scanning
  - Eve2
    - Inexpensive
    - Turn around can be slow, no direct linking to sources, limited doc types, not always stable
  - Plagiarism Finder (Germany)
    - Was inexpensive
    - Spidered off web engines; often engines shut down searches
    - No links to sources
  - Edutie ; Plagiserve (Ukraine)
    - Inexpensive/free
    - Limited doc types, no links to sources, slow turnaround
  - Ithenticate

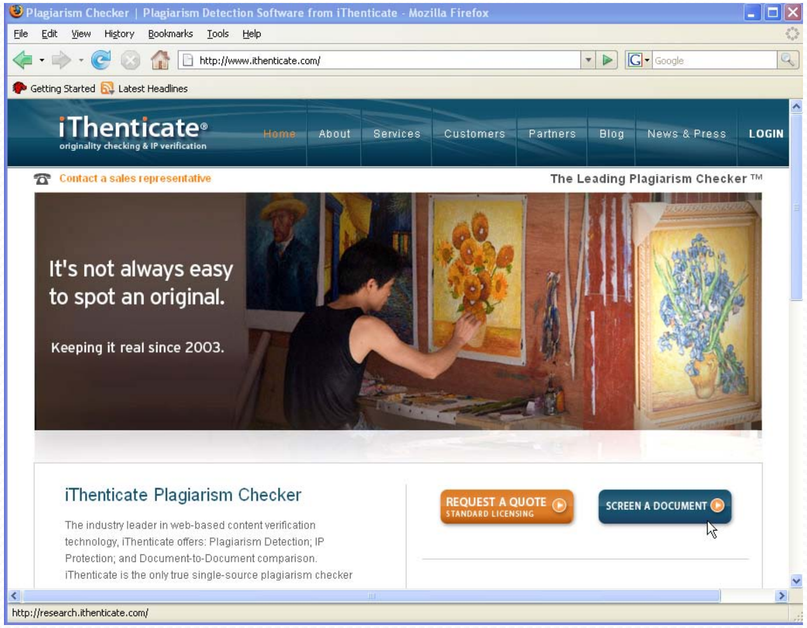
Current Technologies

- Document Comparison
  - wCopyfind
    - U Va product, free, side by side with common text highlighted
    - Limited doc types: old Word, rtf, HTML; doesn't like pics or equations
  - YAP (Yet Another Plague) University of Sydney / MOSS Stanford University – Measures similarity
    - Greater focus on software code

iThenticate

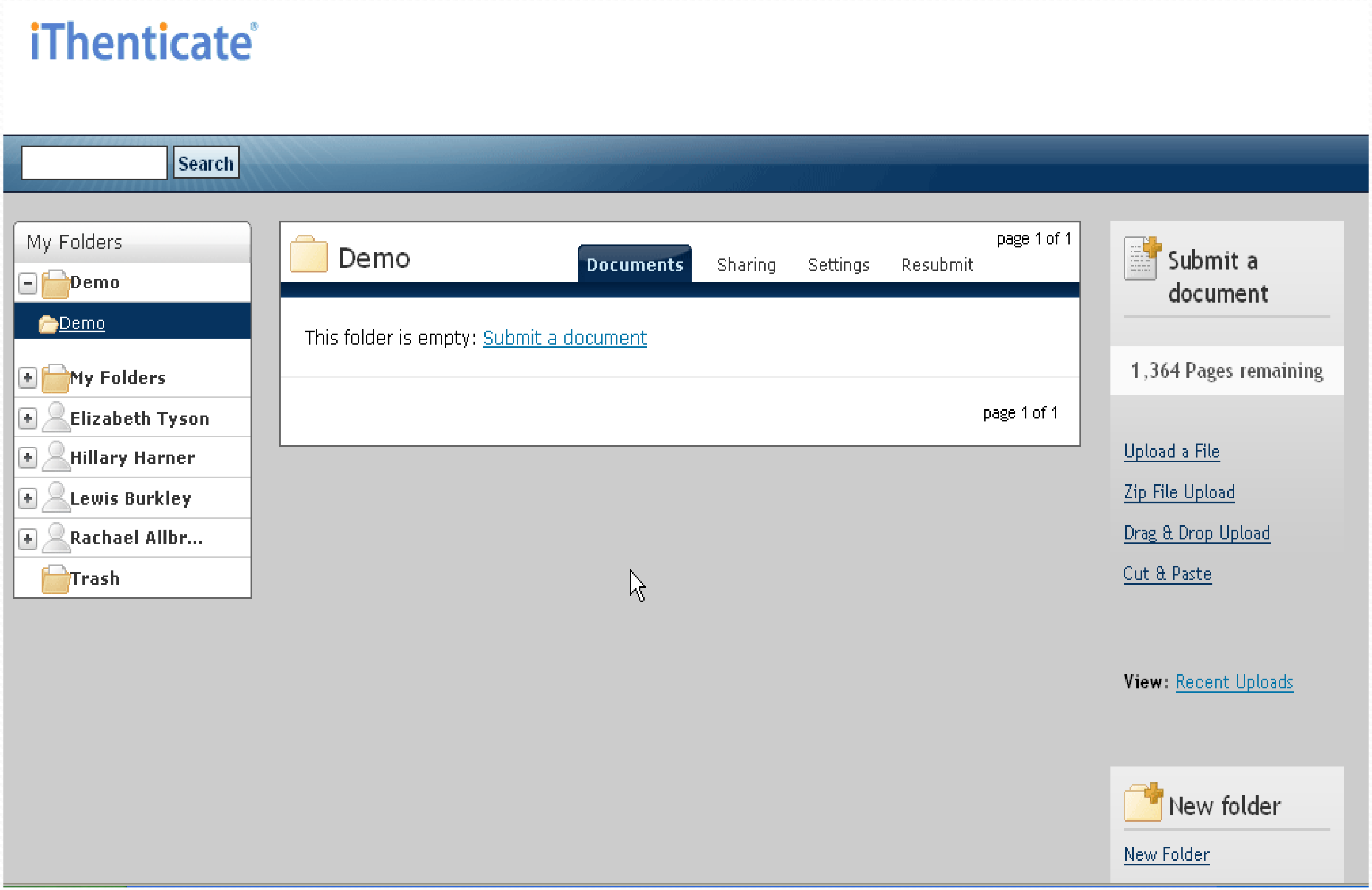
- Developed by the same company as Turnitin.com
  - Expensive but seems to offer greatest power/flexibility
  - Searches internet and scientific journals
  - Many document input formats
  - Turnaround in minutes vs hours/day
  - Provides links to all sources, overall similarity percentage and percentage for each source
  - Identifies similar text in highlights
  - User friendly (interns up and running within a 1-2 days)
  - Confidentiality concerns
  - Documentation is 20 different languages, non-English source materials limited but expanding

iThenticate*



* NSF/OIG does not endorse this or any other commercial plagiarism detection software

How We Analyze for Plagiarism



How We Analyze for Plagiarism

Available Document Repositories

Documents will be compared against these repositories. You may select a subset of repositories by adjusting the Settings for each folder.

- **CrossCheck**
- **Internet**
- **Publications**

How We Analyze for Plagiarism

Manage Users

Profiles | Groups | **Reports** | Sharing | Email

By User / Group | By Month | Set Date Range

Usage Reports

This page displays a snapshot of account usage. You can view more detailed statistics for an individual by clicking on the user's name.

Sort report by clicking on a column title. Click on the plus sign to view users within each group.

Report is not limited by a date range | change

User	Group ↓	Submissions	Page count [1]	Avg Percent Match
+ Group: Unassigned		2,089	6,412	14%
National Science Foundation		2,089	6,412	14%

[1] Approximately 10,000 words per "Page"

page 1 of 1

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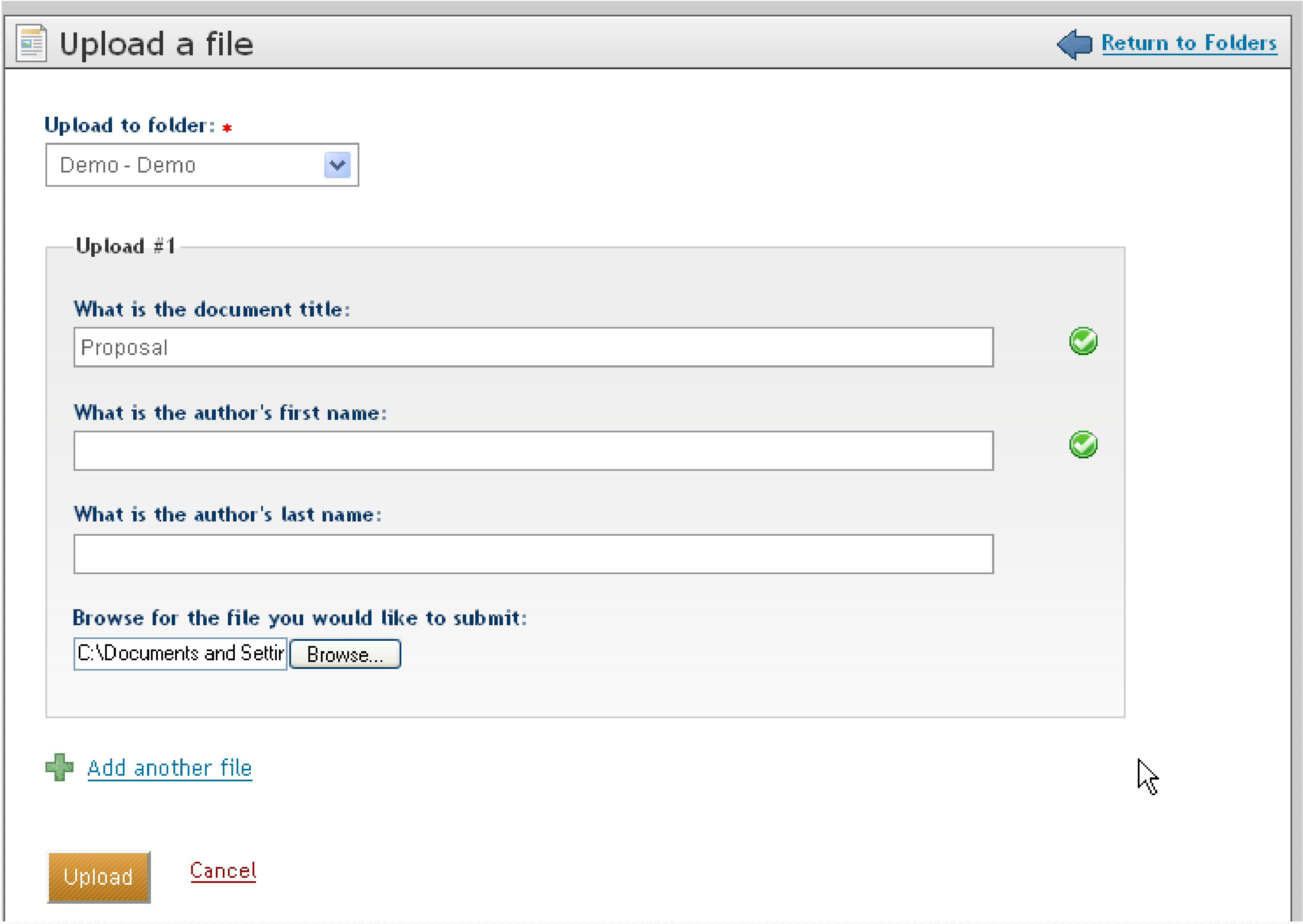

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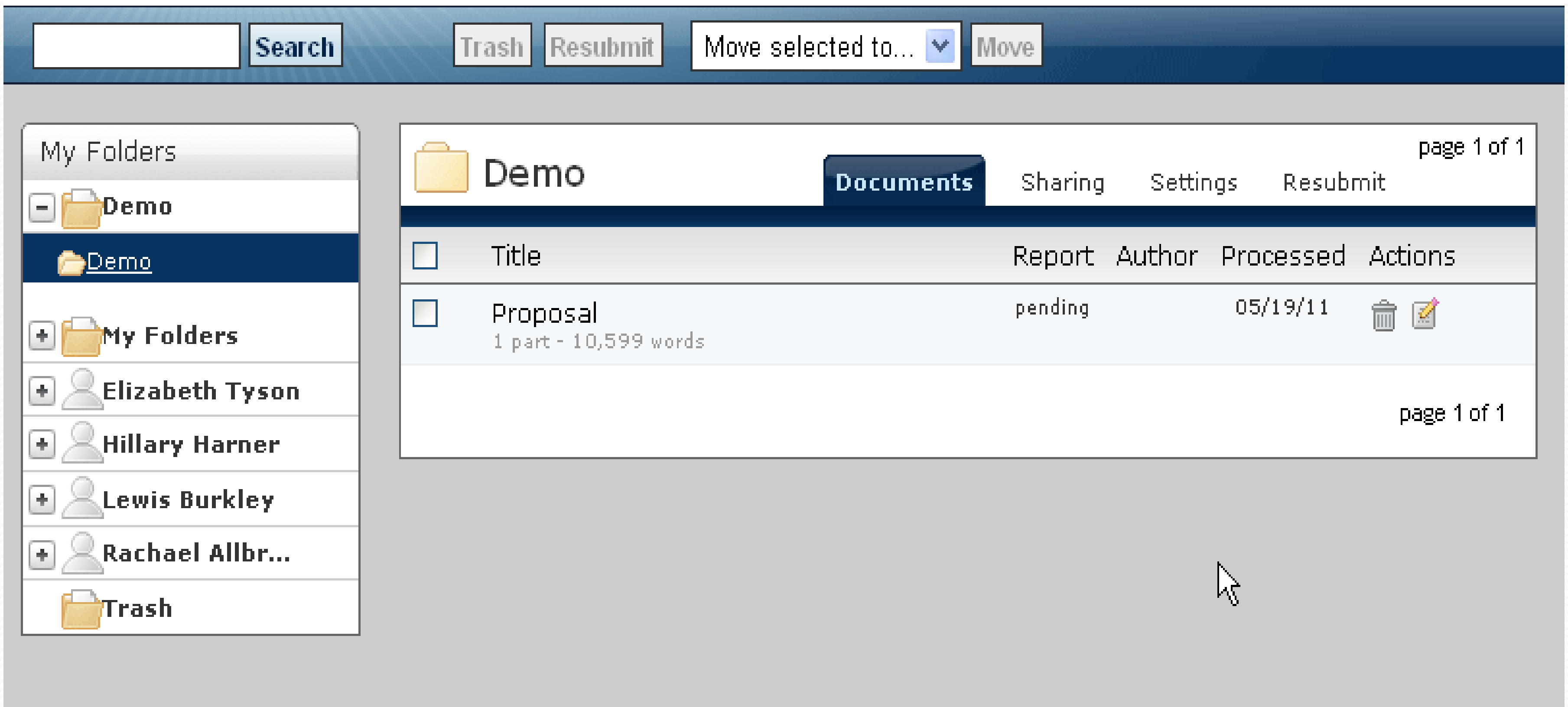

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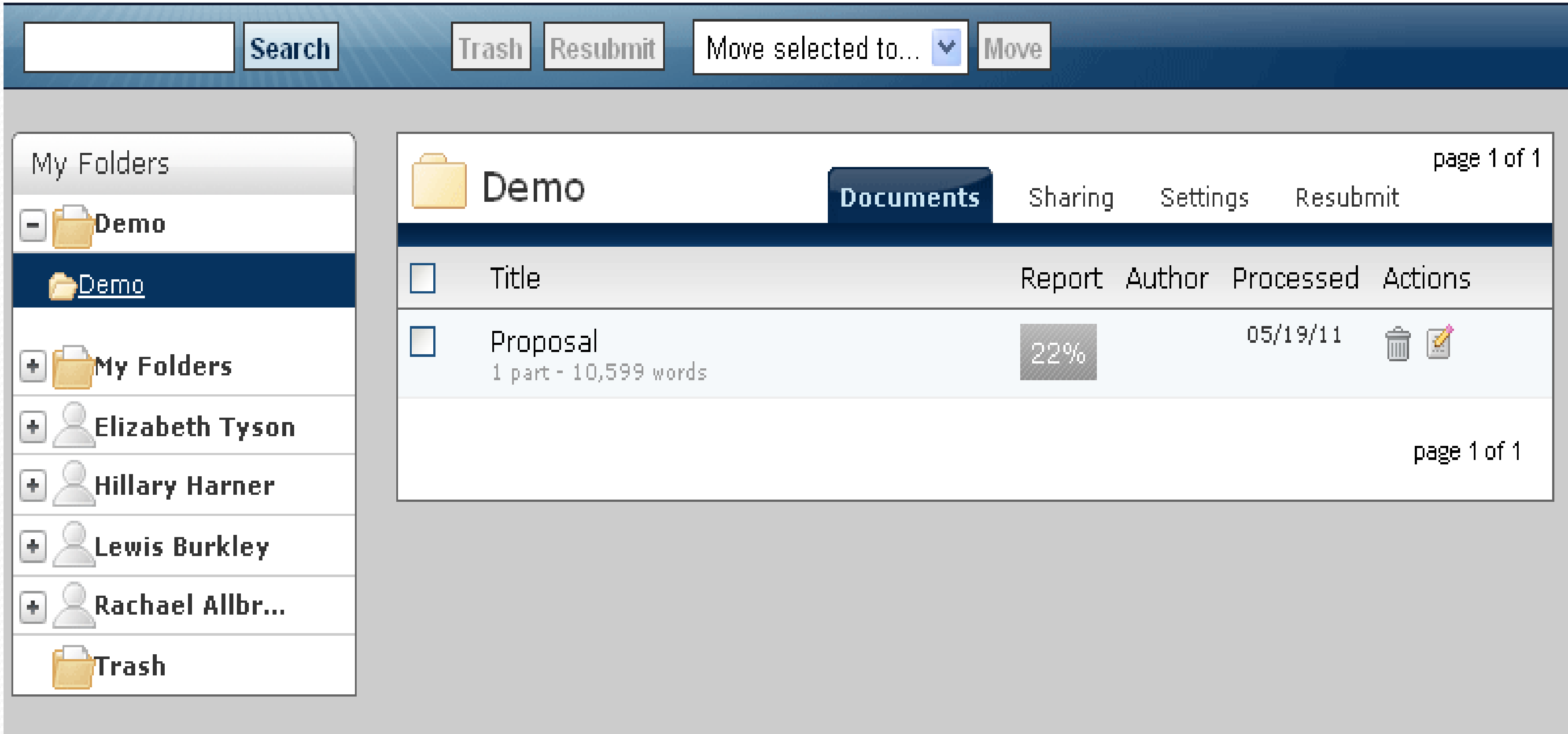

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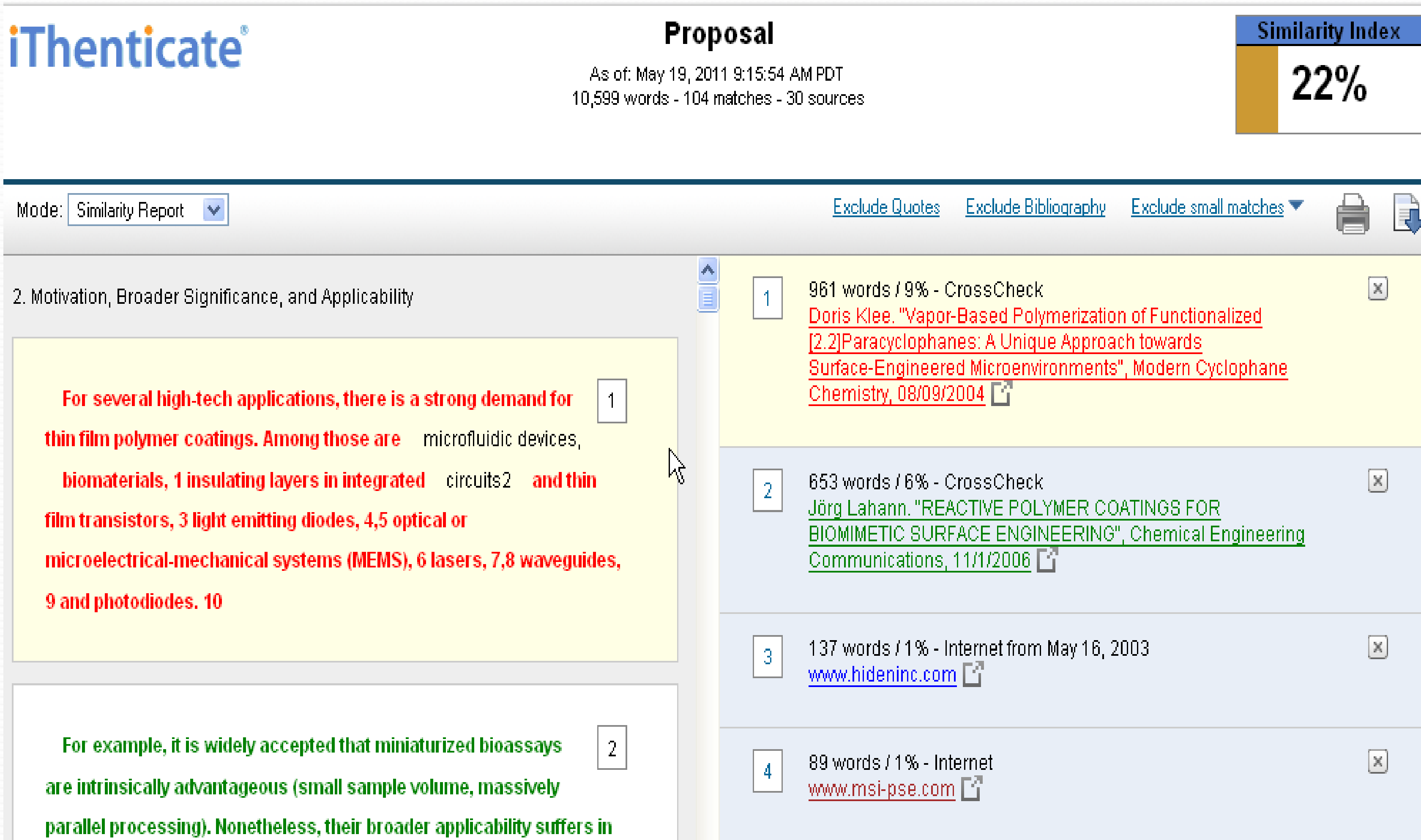

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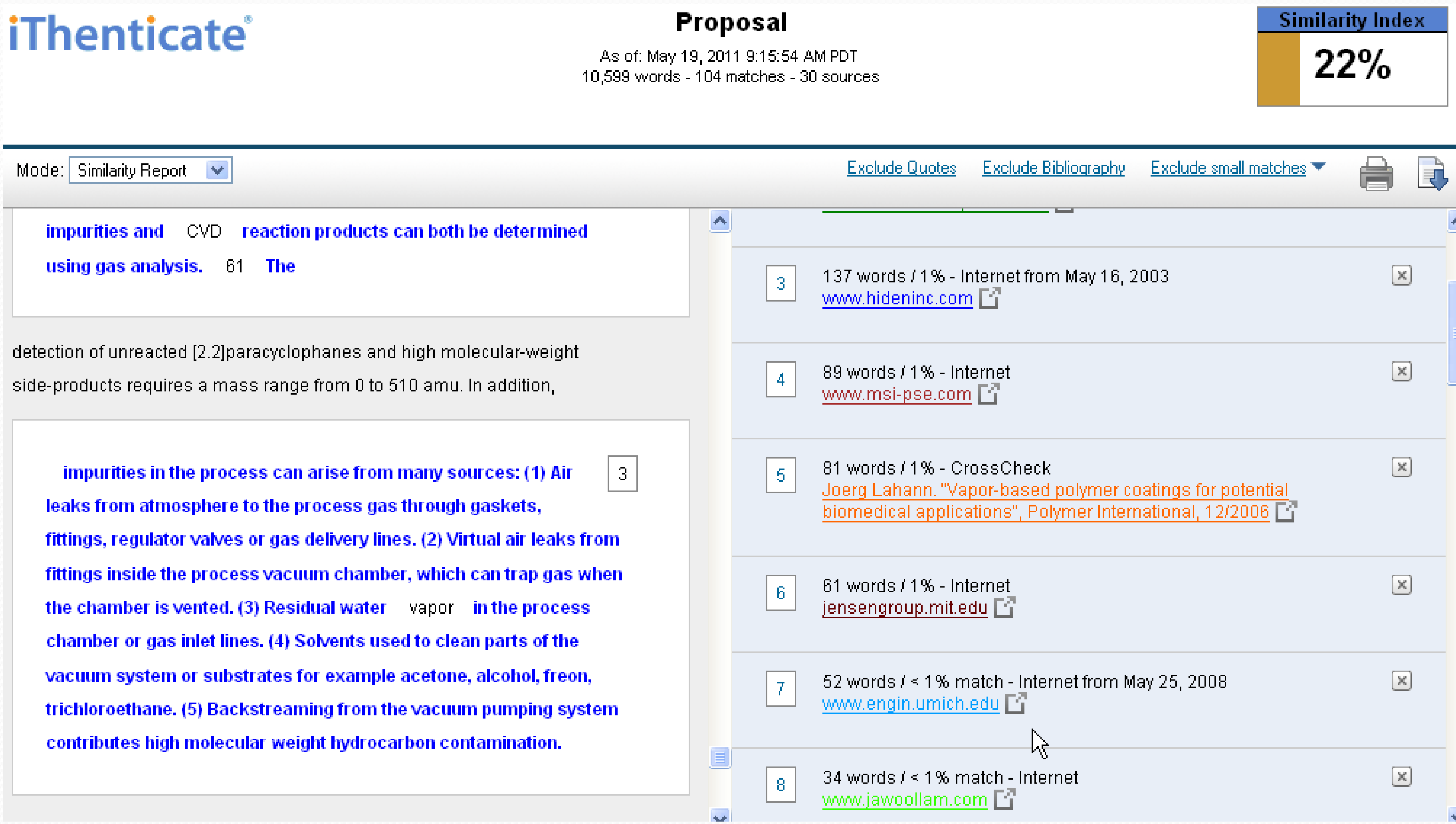

How We Analyze for Plagiarism

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Proposal

As of: May 19, 2011 9:15:54 AM PDT
10,599 words - 104 matches - 30 sources

Similarity Index
22%

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Exclude Quotes | Exclude Bibliography | Exclude small matches

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detection of unreacted [2.2]paracyclophanes and high molecular-weight side-products requires a mass range from 0 to 510 amu. In addition,

impurities in the process can arise from many sources: (1) Air leaks from atmosphere to the process gas through gaskets, fittings, regulator valves or gas delivery lines. (2) Virtual air leaks from fittings inside the process vacuum chamber, which can trap gas when the chamber is vented. (3) Residual water vapor in the process chamber or gas inlet lines. (4) Solvents used to clean parts of the vacuum system or substrates for example acetone, alcohol, freon, trichloroethane. (5) Backstreaming from the vacuum pumping system contributes high molecular weight hydrocarbon contamination. 3

62 For this reason, we propose the integration of a

3

137 words / 1% - Internet from May 16, 2003
www.hideninc.com

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next match:

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guaranteed. This could potentially be reduced by (i) polymer films deposited on the window, and (ii) strain on the glass of the window. Both factors can potentially reduce the light passing through or may induce birefringence, which, in turn, may alter the polarization state of the beam. To minimize birefringence, we will ensure that the beam will enter normal to the plane of the window. In addition, heating the window along with the surrounding will prevent polymer deposition. This will require temperature of above 100 °C. Since the high temperatures may cause additional strain, we will use fused silica windows that are mounted via a viton-based O-ring seal. The windows are relatively inexpensive, and easy to replace, for the case, that polymer deposition may occur after long operation times in spite of the heating.

(2) Issues regarding software integration. The instrument will be communicating through RS-232 or TCP/IP network protocols with an external computer. This will allow commands to be sent to start and end data acquisition as well as retrieving values determined by the data analysis. Eventually, we intend the instrument to be fully integrated as descried in section 5.2.8.

5.2.6. Mass Spectrometer (MS). Monitoring the real time composition of the vapor prior to and during deposition will enhance our fundamental understanding of CVD polymerization, which is a rather unique polymerization type in that it follows a living radical mechanism. Process gas analysis will be an indispensable tool for these fundamental studies.[60] In CVD polymerization, polymer films are made form [2.2]paracyclophanes, which are activated previous to polymerization. The quality of the CVD film depends on impurities in the process gas mixture and also on the operating conditions in the CVD reactor. Process impurities and CVD reaction products can both be determined using gas analysis.[61] The detection of unreacted [2.2]paracyclophanes and high molecular-weight side-products requires a mass range from 0 to 510 amu. In addition, impurities in the process can arise from many sources: (1) Air leaks from atmosphere to the process gas through gaskets, fittings, regulator valves or gas delivery lines. (2) Virtual air leaks from fittings inside the process vacuum chamber, which can trap gas when the chamber is vented. (3) Residual water vapor in the process chamber or gas inlet lines. (4) Solvents used to clean parts of the vacuum system or substrates for example acetone, alcohol, freon, trichloroethane. (5) Backstreaming from the vacuum pumping system contributes high molecular weight hydrocarbon contamination.[62] **P1**

For this reason, we propose the integration of a process gas analysis system consisting of a high performance quadrupole mass spectrometer, a differentially pumped housing and specially designed orifice inlet. The inlet and the detection chamber will be heated to avoid film deposition due to polymerization. The vacuum system is pumped by a turbomolecular pump and backed by a mechanical pump. We also seek to integrate a combination of Faraday and SEM detectors into the system, which will give as excellent precision and flexibility.[63]

5.2.7 Quartz crystal microbalance (QCM). The quartz crystal microbalance is a piezoelectric transducer widely used in vacuum deposition systems. These devices allow a mass change, occurring during a deposition process, to be converted into a resonant frequency change, which is an easily measurable signal. Crystal failures are often observed and can be caused by mode hoping to other (anharmonic) resonant frequencies due to the buildup of composite resonant modes, deviations from theory due to fringing electrode fields developed between the electrodes and the film, and unexpected shifts in fundamental frequency due to stress build up on the crystal surface. We will address these issues twofold: (i) The combination of QCM and SE enables individual calibration that will be conducted in real time and in situ. This will improve the precision of our measurements and also will provide evidence regarding the limitations of the QCM. (ii) The proposal suggests the use of a QCM that features a separate, internal oscillator, which drives the RF circuitry (such as Inficon's XTC-2). In contrast to conventional systems, power is delivered to the crystal as a group of fixed frequency waves. This instrument further includes an intelligent feedback link, which examines the crystal phase and voltage characteristics continuously, while the wave packets are sent. The circuit then corrects the oscillator frequency for the next wave packet and prevents mode hoping and unexpected frequency jumps, as long as the deposition rates large compared to the wave packet frequencies.

5.2.8 RS-485/232 interface board, TC board, and Labview software for online process control. All process components and the QCM will be equipped with either a serial interface (RS 232 or RS 485). The serial interfaces can be integrated through a suitable interface board, e.g. a National Instrument's interface board. Then, all control and monitor operations can be recorded and controlled from a central computer. MS and SE will be integrated via LAN network connections. Finally, the thermocouple output will be immediately transmitted to the computer via a thermocouple board. In this set-up, critical polymerization parameters, such as mass flow, pressure, sublimation and pyrolysis temperature, stage temperature, wall temperature, shutter,

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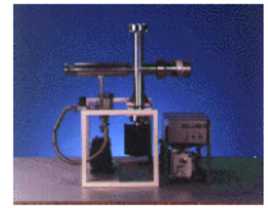
HIDEN ANALYTICAL

Gas Analysers - HPR-50

DQ100 / HPR-50. Gas Analyser for Diamond CVD process monitoring

Diamond film quality can be controlled by monitoring the plasma reaction products. Impurity gases can be determined to PPM levels and lower. The key features of the system are low detection limits for impurities, fast response time and an inert heatable all glass inlet.



- Jet separator inert inlet
- ppb sensitivity
- Inert inlet for characterisation of reactive products
- Trend Analysis providing a quality control processing signature for improved reproducibility and better quality control of deposited film.

In diamond growth a methane and hydrogen gas mixture is used to form a plasma discharge from which diamond film is deposited on a heated electrode. The operating pressure is in the range 20 to 400 Torr and the ratio of the partial pressure of methane to hydrogen is between 0.1 and 10%. The quality of diamond film depends on impurities in the process gas mixture and also on the operating conditions in the plasma reactor. Process impurities and plasma reaction products can both be determined using gas analysis. Impurities in the process can arise from many sources.

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3. Residual water vapour in the process chamber or gas inlet lines. **P1**

4. Solvents used to clean parts of the vacuum system or substrates for example acetone, alcohol, freon, trichloroethane.

5. Backstreaming from the vacuum pumping system contributes high molecular weight hydrocarbon contamination.

6. Outgassing from part of the process cycle for example when a substrate heater is brought to temperature or when the plasma discharge is initiated.

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The Quartz Microbalance in liquid

The quartz crystal microbalance is a piezoelectric transducer widely used in electrochemistry. First attempts were made at the beginning of the eightieth. These devices allows a mass change, occuring during an electrochemical process, to be converted, under some conditions, into a resonant frequency change which is an easily measurable signal. The great interest is due to the high mass sensitivity for studying in situ and in real time an electrochemical reaction. Q1

The basic principle is based on the chronometric properties of the resonant device : a resonator in contact with a solution, in general a quartz crystal, is inserted in an electronic circuit which delivers a high stable signal, the entire set up being called oscillator. Whatever the perturbation onto the top of the resonator, this leads immediately to a change of the oscillation frequency, measurable parameter. Through the Sauerbrey relationship, the estimated mass change is calculated via the corresponding frequency change. At 6 MHz, the mass sensitivity reaches 2.5 ng per Hertz with a 0.2 cm^2 active surface which is equivalent to a fraction of adsorbed oxygen onto the surface.

This sensitive tool is developped in our laboratory to get subleties about electrochemical reactions : on the one hand, for the electrochemical kinetic by measuring electrogravimetric [1,2], and on the other hand, for the viscoelastic properties of the added film [3]. Endly, ultra-sensitive transducers are studied to determine with a good accuracy intermediate species involved in various processes [4].

References :

[1] "*a.c. electrogravimetry on conducting polymers. Application to polyaniline*", C. Gabrielli, M. Keddam, N. Nadi et H. Perrot, Electrochim. Acta, 44 (1999) 2095-2103.

[2] "*Separation of ionic and solvent transport during charge compensation processes in electroactive polymers by a.c. electrogravimetry*", C. Gabrielli, M. Keddam, H. Perrot, M.C. Pham et R. Torresi, Electrochim. Acta., 44 (1999) 2095-2103.

[3] "*Étude et mise au point de transducteurs ultra-sensibles fonctionnant en milieu liquide*", D. Bouché-Pillon, Thèse de Doctorat Paris VI, Novembre 1996.

[4] "*Validation of antibody-based recognition by piezoelectric transducers through electroacoustic admittance analysis*", K. Bizet, C. Gabrielli, H. Perrot et J. Therasse, Biosensors and bioelectronics, 13 (1998) 259-269.

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5.2.8 RS-485/232 interface board, TC board, and Labview software for online process control. All process components and the QCM will be equipped with either a serial interface (RS 232 or RS 485). The serial interfaces can be integrated through a suitable interface board, e.g. a National Instrument's interface board. Then, all control and monitor operations can be recorded and controlled from a central computer. MS and SE will be integrated via LAN network connections. Finally, the thermocouple output will be immediately transmitted to the computer via a thermocouple board. In this set-up, critical polymerization parameters, such as mass flow, pressure, sublimation and pyrolysis temperature, stage temperature, wall temperature, shutter,

Z-match Method

It is generally accepted that when the mass loading from the deposit causes a change in frequency of less than 2% of the frequency of the unloaded crystal, Sauerbrey's equation can be used to obtain accurate results in thin-film thickness calculations[9]. As the thickness of the film increases, the Sauerbrey equation must be extended to incorporate the elasticity of the deposit. Lu and Lewis[10] gave a simple equation (eqn. 5) for the calculation of the dependence of Δf on Δm, which is currently applied by most QCM users to calculate rigid thin-film thicknesses in gas phase depositions.

$$\Delta m = [(N_q \cdot \rho_q)/(\pi \cdot Z \cdot f_L)] \cdot \tan^{-1}[Z \cdot \tan[\pi \cdot (f_U - f_L) / f_U]] \qquad \text{(eqn. 5)}$$

where,

Δm = change in mass per unit area in g/cm^2,

N_q = Frequency Constant for AT-cut quartz crystal = 1.668 x 10^{13} Hz Å,

ρ_q = density of quartz = 2.648 g · cm^{-3},

f_U = frequency of unloaded crystal (prior to deposition) in Hz,

f_L = frequency of loaded crystal in Hz,

Z = Z-Factor of film material = $[(\rho_q \cdot \mu_q) / (\rho_f \cdot \mu_f)]^{1/2}$,

ρ_f = density of film material in g · cm^{-3},

μ_q = shear modulus of quartz = 2.947 x 10^{11} g · cm^{-1} · s^{-2},

μ_f = shear modulus of film material.

This analysis of frequency changes, including the acoustic impedances of the quartz and film, is often called the "Z-match" method. The accuracy of the mass load and film-thickness calculation is often limited by how well the Z-Factor and density of the material are known. Density and Z-Factor values are typically very close to bulk values. The bulk density and shear modulus values for common film materials can be found in many material reference handbooks.

The Lu and Lewis equation is generally considered to be a good match to the experimental results[11] for frequency changes up to 40% (relative to the unloaded crystal). Keep also in mind that the Z-match equation strictly applies to "rigid" deposits. Films which behave viscoelastically, such as some organic polymer films with large thickness or viscosity, will exhibit significant deviations from both equations 1 and 5.

R1 Crystal failures are also often seen before a 40% shift in frequency is reached. Common problems are (1) shorts in the crystal electrodes due to excessive buildup, (2) mode hopping to other (anharmonic) resonant frequencies due to the buildup of composite resonant modes, (3) deviations from theory due to fringing electrode fields developed between the electrodes and the film, (4) unexpected shifts in fundamental frequency due to stress build up on the crystal surface, (5) splitting of source material resulting in non-uniform films, etc.

guaranteed. This could potentially be reduced by (i) polymer films deposited on the window, and (ii) strain on the glass of the window. Both factors can potentially reduce the light passing through or may induce birefringence, which, in turn, may alter the polarization state of the beam. To minimize birefringence, we will ensure that the beam will enter normal to the plane of the window. In addition, heating the window along with the surrounding will prevent polymer deposition. This will require temperature of above 100 °C. Since the high temperatures may cause additional strain, we will use fused silica windows that are mounted via a viton-based O-ring seal. The windows are relatively inexpensive, and easy to replace, for the case, that polymer deposition may occur after long operation times in spite of the heating.

(2) Issues regarding software integration. The instrument will be communicating through RS-232 or TCP/IP network protocols with an external computer. This will allow commands to be sent to start and end data acquisition as well as retrieving values determined by the data analysis. Eventually, we intend the instrument to be fully integrated as descried in section 5.2.8.

5.2.6. Mass Spectrometer (MS). Monitoring the real time composition of the vapor prior to and during deposition will enhance our fundamental understanding of CVD polymerization, which is a rather unique polymerization type in that it follows a living radical mechanism. Process gas analysis will be an indispensable tool for these fundamental studies.[60] In CVD polymerization, polymer films are made form [2.2]paracyclophanes, which are activated previous to polymerization. The quality of the CVD film depends on impurities in the process gas mixture and also on the operating conditions in the CVD reactor. Process impurities and CVD reaction products can both be determined using gas analysis.[61] The detection of unreacted [2.2]paracyclophanes and high molecular-weight side-products requires a mass range from 0 to 510 amu. In addition, impurities in the process can arise from many sources: (1) Air leaks from atmosphere to the process gas through gaskets, fittings, regulator valves or gas delivery lines. (2) Virtual air leaks from fittings inside the process vacuum chamber, which can trap gas when the chamber is vented. (3) Residual water vapor in the process chamber or gas inlet lines. (4) Solvents used to clean parts of the vacuum system or substrates for example acetone, alcohol, freon, trichloroethane. (5) Backstreaming from the vacuum pumping system contributes high molecular weight hydrocarbon contamination.[62] **P1**

For this reason, we propose the integration of a process gas analysis system consisting of a high performance quadrupole mass spectrometer, a differentially pumped housing and specially designed orifice inlet. The inlet and the detection chamber will be heated to avoid film deposition due to polymerization. The vacuum system is pumped by a turbomolecular pump and backed by a mechanical pump. We also seek to integrate a combination of Faraday and SEM detectors into the system, which will give as excellent precision and flexibility.[63]

5.2.7 Quartz crystal microbalance (QCM). The quartz crystal microbalance is a piezoelectric transducer widely used in vacuum deposition systems. These devices allow a mass change, occurring during a deposition process, to be converted into a resonant frequency change, which is an easily measurable signal. **Q1** Crystal failures are often observed and can be caused by mode hoping to other (anharmonic) resonant frequencies due to the buildup of composite resonant modes, deviations from theory due to fringing electrode fields developed between the electrodes and the film, and unexpected shifts in fundamental frequency due to stress build up on the crystal surface. **R1** We will address these issues twofold: (i) The combination of QCM and SE enables individual calibration that will be conducted in real time and in situ. This will improve the precision of our measurements and also will provide evidence regarding the limitations of the QCM. (ii) The proposal suggests the use of a QCM that features a separate, internal oscillator, which drives the RF circuitry (such as Inficon's XTC-2). In contrast to conventional systems, power is delivered to the crystal as a group of fixed frequency waves. This instrument further includes an intelligent feedback link, which examines the crystal phase and voltage characteristics continuously, while the wave packets are sent. The circuit then corrects the oscillator frequency for the next wave packet and prevents mode hoping and unexpected frequency jumps, as long as the deposition rates large compared to the wave packet frequencies.

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Concluding comments

- Substantive allegations of research misconduct are on the rise
- Technology makes it easier to cut-and-paste text into papers/proposals
- Nature of plagiarism has changed (large blocks vs small blocks, multiple sources)
- iThenticate seems to be the current leader (OIG uses but does not endorse)
- Other tools are available with more limited capabilities
- Growth of industry indicator of growing problem

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