-Collaborators-

**Experiment and Discussion**

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**SPM Measurement and Discussion**

ISJ: Technical Committee on Toner Technology

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**Estimation of Charge, Simulation and Discussion**

ISJ: Technical Committee on Simulation Technology

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Agenda

1. Introduction
2. Objective
3. Estimation of Charge Distribution with SPM Measurement
4. Estimation of Adhesion with Charge Distribution obtained from SPM Measurement
5. Analysis of Toner Adhesion with Simulation
6. Conclusion
Electrostatic Adhesion

Measurement: 1 nN ~ 50 nN ~ 100 nN
Theory (Mirror Force): ~ 2 nN ~

Measurements indicate forces on the order of 10x larger than what would be predicted from the mirror force theory.
SPM Potential Measurement

Estimation of Charge

Charge Distribution on a Toner

Estimation of Adhesion (Simulation)

Adhesion Measurement

Our Study

J. Hirabayashi (2014)

M. Kadonaga (2014)

SPM Potential Measurement
Objective

To investigate adhesion mechanism with SPM and simulation

Step 1  : Estimation of charge distribution with SPM measurement

Step 2  : Estimation of adhesion with the charge distribution

Step 3  : Analysis of adhesion with simulation
Step 1: Estimation of charge distribution with SPM measurement

Jun HIRABAYASHI (Canon Inc.)
Toner Charging

Sample

ISJ standard carrier

Model Toner

polystyrene particle

Additive

Fumed Silica (Negative)

5µm

Mixing and Charging

Toner

Carrier

Carrier

Toner
Toner Charging

Sample

ISJ standard carrier N-02 (T/D: 5%)

AEROSIL Fumed Silica (Nega) RY 200 (0.5部)

Soken chemical & Engineering SX500H (polystyrene particle)
We should estimate a charge distribution from the potential distribution.

Toner \( Q = 2 \sim 3 \ fC \) \( D = 6 \ \mu m \)

Polystyrene + Additive (Silica)

Sample

ISJ Standard Carrier

Mixed and toner is charged.

Surface form and Potential

SPM (2013: Canon Tada)
Theoretically speaking, we can estimate charge distribution with a system response.
Electrostatic simulation of SPM is carried out.

Relation between the position of a charge and induced potential of the probe is obtained.

System response is estimated from a 3D-electrostatic simulation of SPM.
Estimation of Charge Distribution

Potential × \( \text{Inverse of System Response}^{-1} \) = Estimated Charge

Potential from SPM × \( \text{Inverse of System Response}^{-1} \) = Estimated Charge

Charge distribution on a small area is obtained.
Estimation of Charge on the Whole Surface of a Toner

Charge on a small area -> Copy -> Expand to Cube

Projection to Sphere -> Sphere Mapping

Charge distribution on the whole surface of a toner is obtained.
Step 1: Estimation of charge distribution with SPM measurement shows non-uniform charging!
Step 2: Estimation of adhesion with the charge distribution
Simulation Model (FDM)

1. Mesh Making/Setting Toner
2. Setting Charge
3. Electrostatic Calculation
4. Estimation of Adhesion to a Grounded Plane with Maxwell Stress Tensor
Adhesion with Charge Distribution Estimated from SPM Measurement

Electrostatic Simulation

Charge Distribution Estimated from Step 1

Deposit on the grounded plane

Result

\[ Q = 2.5 \text{fC} \]

Adhesion: 135nN

(Mirror Force: 1.6nN)

Appropriate adhesion is obtained with the charge distribution obtained from Step 1.
Appropriate distribution of adhesion is obtained.
Step 2: Estimation of adhesion with charge distribution offers an appropriate adhesion value!
Step 3: Analysis of adhesion with simulation

Masami KADONAGA (Ricoh)
Anatomy of Adhesion

SPM measurements and estimations of charge are laborious work.

Artificial charge-distributions are made by random number.

Calculate adhesion
Estimated Adhesion of Artificial Toner

N=1000 \( q=3.4fC \) With Charge Patch on the South Pole

- Estimated Adhesion of Artificial Toner
  - Appropriate adhesion is obtained with artificial toners.

Graph:
- Average Adhesion: 27nN (N=1000)

- Y-axis: Number
- X-axis: Adhesion [nN]

Appropriate adhesion is obtained with artificial toners.
Effect of Location of Charge Patch

$F_E$ (Whole Toner)

$F_{EN}$ (Northern Hemisphere) $\ll F_{ES}$ (Southern Hemisphere)

Charge of Southern Hemisphere is dominant.
Num. of Charge Patch/Size vs. Adhesion

Patch Radius: 0.4 μm  Q=3.4fC

Patch Radius: 0.5 μm  Q=3.4fC

Patch Radius: 1 μm  Q=3.4fC

Patch Radius: 1.5 μm  Q=3.4fC

Q=3.4fC, N=100
Non-uniform charging enhances adhesion.
Conclusion

Step 1: Estimation of charge distribution with SPM measurement shows non-uniform charging!

Step 2: Estimation of adhesion with the charge distribution offers an appropriate adhesion value!

Step 3: Anatomy of adhesion with simulation Charge of Southern Hemisphere is dominant.
Potential Measurement of Charge Distribution on a Toner

Adhesion for partly charged toners

SPM potential measurement

Estimation of Adhesion (Simulation)

Charge Distribution on a Toner

Estimation of Charge

Our Study

J. Hirabayashi (2014)

M. Kadonaga (2014)

Big Picture of Adhesion Analysis