

Title: Dynamic Wetting on Flexible, Adaptive and Switchable Polymer Carpets**Principal investigator:**

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Project Description**Abstract**

In the proposed work, we will synthesize stimuli-responsive *polymer carpets* (covalently grafted polymer brushes on flexible, ultrathin nanosheets) by means of a defined surface-initiated polymerization technique and investigate the wetting dynamics on the adaptive surfaces. Depending on the brush grafting density and thickness, as well as on its swelling by liquids, the mechanochemical forces of the attached brush induces strong buckling of the entire *polymer carpet* and dramatically changes the morphology of the composite (strong buckling). This in turn, dramatically changes the wetting behavior of liquids on such surfaces. We will investigate the range, dynamics and reversibility of the morphology change and thus, wetting behavior on these composites as a function of polymer brush parameters (grafting density, thickness), type of polymer and stimulus (temperature, pH, solvent). Furthermore, *patterned polymer brushes* will be investigated as patterning induces directed buckling that should result in a strong anisotropic and dynamic wetting behavior.

1 State of the art and preliminary work

Polymer brushes are, dense, end-grafted linear polymers on interfaces of ideally uniform chain length and a unique example for flexible, adaptive and switchable surface coatings [1]. They react collectively and spontaneous to environmental changes that effect the solvent quality of the respective polymer (collapse/swollen state). Because of the polymer high molar mass and brush thickness, the surface property contrasts of polymer brushes are augmented. Extensive research has been performed on the adsorption, adhesion and wetting characteristics of homo- diblock-mixed and patterned polymer brush systems [1] and very early, theoretical predictions of the unique wetting properties of polymer brushes (entropic effects because of polymer surface crowding) has been experimentally verified [JO1]. Beyond the intriguing wetting characteristics of brush surfaces, the **mechanochemistry of dense brushes** came recently into the focus of intense research [2]. Mechanochemistry describes chemical reactions caused by mechanical forces. Best known is the chain scission of polymers caused by strong external shear recognized by Staudinger already in 1930. The mechanochemical forces of polymer brush systems scale with the chain length as well as with the grafting density. Additional external stimuli strongly alter the mechanochemistry in brush systems (swelling-collapse transition) and even result in irreversible C-C bond scission and polymer degrafting in dense brush systems [JO1, JO2, 4, 13]. Alternatively, reversible mechanochemical brush systems or "soft-mechanochemistry" with brushes are till now restricted to switchable surface screening systems and brushes on elastomers (PDMS) [3].

In 2010 we introduced a new polymeric material, the so-called **polymer carpets** (PC) [JO3]. PCs are polymer brushes that are not attached to a bulk material but to an ultrathin nanosheet ($d \leq 1-10$ nm). PCs are surprisingly robust, can be freestanding or supported by but not bound to a substrate. The entire composite is mainly comprised of the polymer brush and typically of an extreme aspect ratio of 10^4-10^5 (thickness in the nanometer and area in the cm^2 range). A collapse of the polymer of PCs in poor solvents result in an extreme and reversible **buckling** of the entire composite because of strain release and dramatic changes of its physical properties [JO3]. E.g. a PC with a 200 nm thick dense polystyrene (PS) brush shows a buckling amplitude of 1.5 μm . However, the buckling strain release (amplitude and frequency) scales with the brush thickness and has a threshold of around $d = 50$ nm. The dramatic topography changes of PCs by the swelling-collapse transition of the polymer brush has a significant influence on the wetting of liquids on the PC surface. While a PC with a PS brush of a thickness below the buckling threshold ($d=19$ nm) shows a standard static water contact angle of $\Theta_s = 90^\circ$, a buckled PS-PC with $d = 195$ nm strongly dewet the water with a contact angle of $\Theta_s = 135^\circ$. The mechanochemical aspects of dense polymer brushes on rigid solids and on flexible PCs are outlined in Fig. 1.

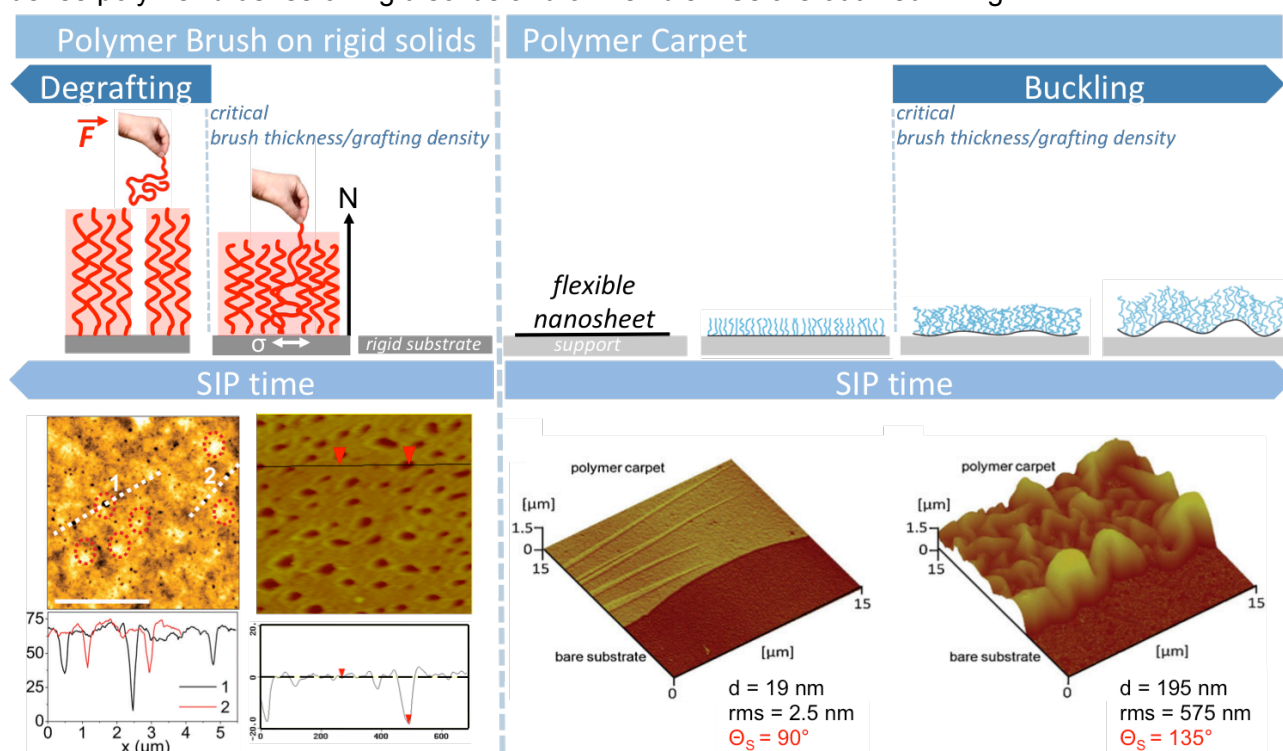


Fig. 1: Mechanochemistry and strain release of dense polymer brushes on solids (left) and flexible polymer carpets (PCs) (right). While on solids, strain in dense polymer brushes is released by irreversible degrafting of polymer chains that are noticeable as holes in the brush layer (left below), flexible PCs react with significant buckling above a critical brush layer thickness. The wrinkled topography augments the wetting behavior (right below). A thin polystyrene PC shows a typical $\Theta_s = 90^\circ$ value while the buckled PC is strongly hydrophobic ($\Theta_s = 135^\circ$). From [2, JO1, JO2, JO3].

Reversible buckling of PCs were observed upon changes of the solvent quality inducing the collapse-swelling transition of the brush. Again, the dramatic morphological change of the PC simultaneously changes their physical properties i.e. surface wetting. Preliminary observation suggests a very fast materials responds (less than 1 sec), however, no detailed investigations were made. Fig. 2A shows the reversible buckling transition of poly(4-vinylpyridine) PCs (P4VP-PC) by water/ ethanol as well as pH. The switching was found to be instantaneous and fully reversible for at least 15 cycles.

Patterned Polymer carpets (PPC) were prepared by electron lithography [JO4]. PC properties were found to be analogue to homogeneous PCs but show a distinct **directed buckling** only if the patterning dimensions are similar to the buckling wavelength. This is in agreement with earlier observations by Hendricks and Lee for a very different but also strained layer system (SiO₂/PDMS) [5]. This phenomenon is of high interest for the proposed work as reversible directed buckling should result in a **strongly anisotropic wetting behavior** of the PCs. However, no investigations of this have been made so far.

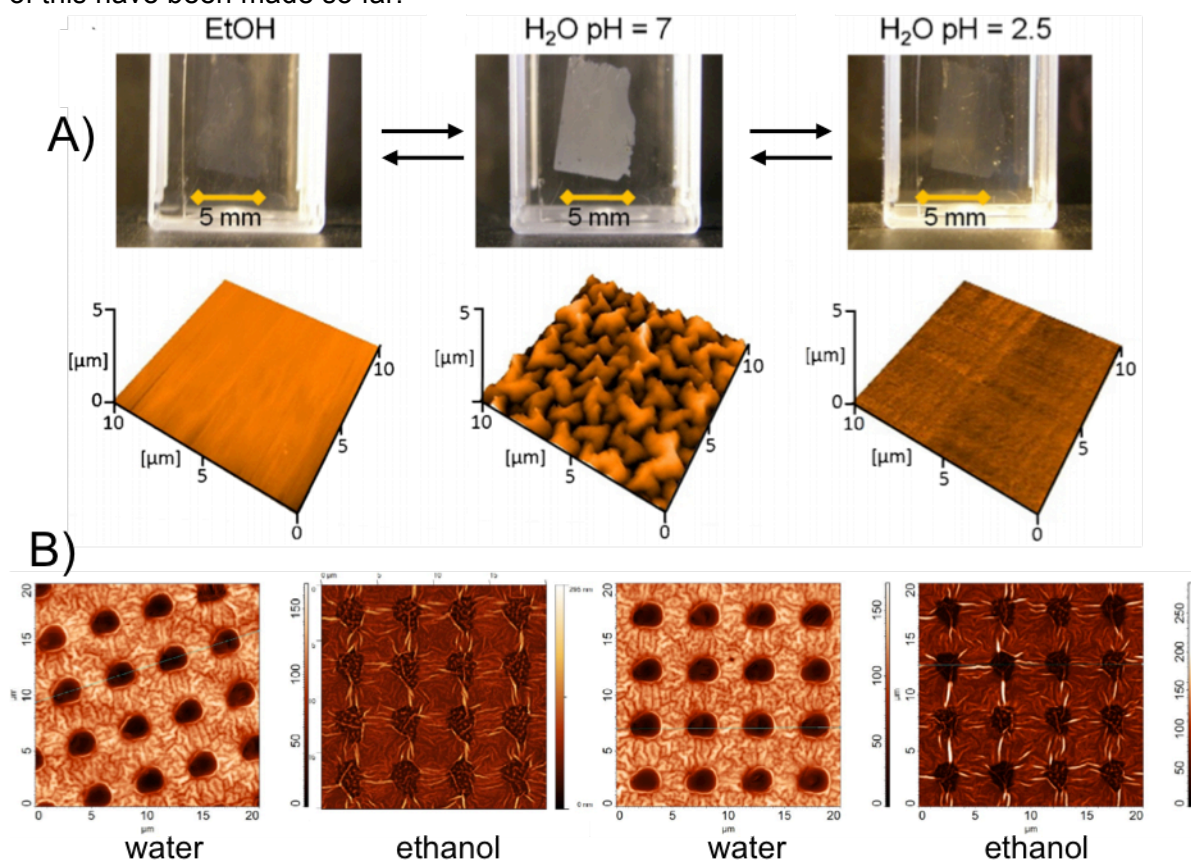


Fig. 2: Reversible buckling of poly(4-vinylpyridin) polymer carpets (P4VP-PCs) on glass support by solvent quality. A) Under good solvent conditions (ethanol or water pH 2.5) the PC is transparent but become immediately opaque in a poor solvent such as water (photos above). This correlates with the brush collapse and dramatic topography change as verified by AFM height scans in the respective solvents (below). B) A micropatterned P4VP-PC shows an analogue behavior but with directed buckling. From [JO3, JO4].

Surface-initiated polymerization (SIP) or the "grafting from" approach is the technique of choice or the preparation of dense and defined polymer brushes. In SIP, a surface is functionalized with an initiating layer and monomer conversion results in polymer growth at typically high grafting density. While e.g. the robust free radical SIP (FR-SIP) results in meaningful brush systems, crosslinking and the higher polymer dispersion are disadvantages. Ideally, living ionic or controlled radical SIP modes result in linear, dense and low dispersed polymer brush systems. Especially the controlled radical SIP (SI-CRP) techniques are currently widely used for brush preparation, as they are robust and reliable [6]. Recently, we have developed a new, robust and rather simple SI-CRP mode, the **surface-initiated Cu(0)-mediated controlled radical polymerization (SI-CuCRP)** [JO2, JO5-JO8]. The SI-CuCRP is strictly surface confined, can be performed at room temperature, without inert conditions, with minimal monomer amounts, convert all vinyl monomers suitable for radical polymerization and is the fastest SIP reaction reported so far. Importantly, the resulting brushes are of very high grafting density of strictly linear and low dispersed polymer chains. Moreover, the SI-CuCRP allows the direct preparation of polymer brush gradients, patterned brushes and -for the

first time- higher order block copolymer brushes (up to decablocks) [JO8]. The very simple and straightforward preparation of polymer brushes by SI-CuCRP from an initiator (BIBB) bearing surface is shown in Fig. 3.

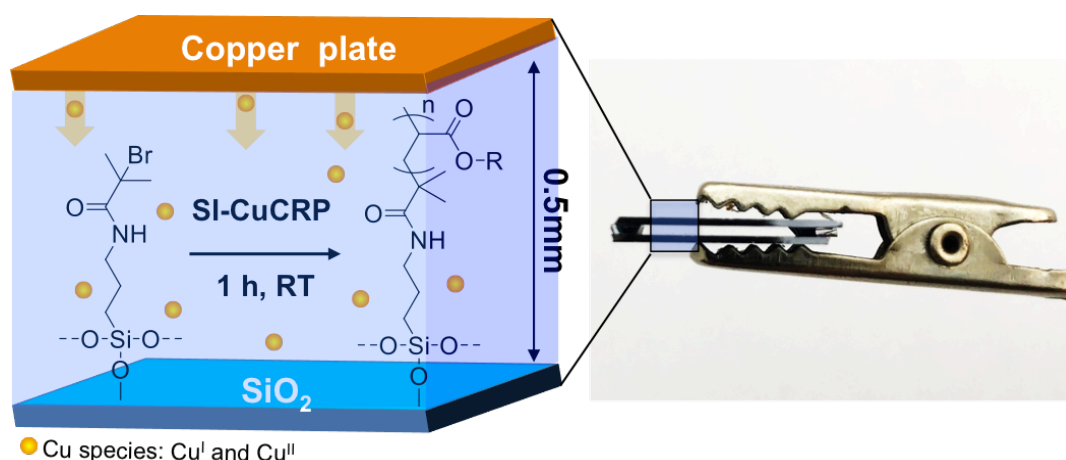


Fig. 3: Surface-initiated Cu(0)-mediated controlled radical polymerization (SI-CuCRP) for polymer brush synthesis. A substrate, bearing a standard CRP initiator (BIBB) monolayer is sandwiched with a copper plate at a distance of approx. 0.5 mm. The gap is filled with the monomer and a copper ligand (PMDTA) in water. After approx. 1h at room temperature and ambient conditions the monomer is converted to a dense, thick and homogeneous brush. Left: reaction scheme. Right: Experimental set-up. From [JO8].

While our initial work on PCs was performed using FR-SIP techniques on crosslinked self-assembled monolayers (carbon nanomembranes) [JO3, JO4], graphene [JO9] or hydrogenated graphene [JO10], we will employ the SI-CuCRP for the PCs in this project to ensure an optimal structure-property relationship. Of direct relevance for this project is the new possibility to prepare hydrophobic polymer brushes and multiblock brushes in water by the "on water" SI-CuCRP [JO8].

1.1 Project-related publications

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- [JO5] T. Zhang, Y. Du, F. Müller, I. Amin, R. Jordan, **Surface-initiated Cu(0) mediated controlled radical polymerization (SI-CuCRP) using a copper plate** *Polym. Chem.* **2015**, 6, 2726-2733.
- [JO6] E. S. Dehghani, Y. Du, T. Zhang, S. N. Ramakrishna, N. D. Spencer, R. Jordan, E. M. Benetti, **Fabrication and Interfacial Properties of Polymer Brush Gradients by Surface-Initiated Cu (0)-Mediated Controlled Radical Polymerization** *Macromolecules* **2017**, 50, 2436-2446.
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- [JO8] Y. Che, T. Zhang, Y. Du, I. Amin, C. Marschelke, R. Jordan, **"On water" Surface-initiated Polymerization of Hydrophobic Monomers** *Angew. Chem. Int. Ed.* **2018**, in print. (DOI:10.1002/anie.201809100)
- [JO9] M. Steenackers, A. M. Gigler, N. Zhang, F. Deubel, M. Seifert, L. H. Hess, C. H. Y. X. Lim, K. P. Loh, J. A. Garrido, R. Jordan, M. Stutzmann, I. D. Sharp, **Polymer Brushes on Graphene** *J. Am. Chem. Soc.* **2011**, *133*, 10490-10498.
- [JO10] M. Seifert, A. Koch, F. Deubel, T. Simmet, L. Hess, M. Stutzmann, R. Jordan, J. A. Garrido, I. Sharp, **Functional Polymer Brushes on Hydrogenated Graphene** *Chem. Mater.* **2013**, *25*, 466-470.

1.1.1 Articles published by outlets with scientific quality assurance, book publications, and works accepted for publication but not yet published

none

1.1.2 Other publications, Patents

none

2 Objectives and work programme

2.1 Anticipated total duration of the project

3 years, starting on the 1.10.2019

2.2 Objectives

The general aim of this project is the synthesis of highly defined polymer carpets (PCs) on ultrathin nanosheets by means of surface-initiated Cu(0)-mediated controlled radical polymerization (SI-CuCRP) and the investigation of their wetting behavior. As liquids we will restrict the project on simple liquids, mainly water of different ion strength as well as aqueous mixtures with polar organic solvents (e.g. ethanol) to trigger the swelling-collapse of the PC. In collaboration with H. Riegler and S. Karpitschka detailed studies of the dynamic wetting behavior of PCs will be performed. For M. Tanaka (Univ. Heidelberg) we will provide tailored brush and PCs systems for his studies on lipid vesicle wetting and with T. Pfohl brush modification of flexible membranes performed.

Specifically, we will investigate the

- influence of the polymer brush parameters (thickness, grafting density) on the buckling and wetting behavior
- influence of polymer composition (stimuli-responsiveness) on the buckling and wetting behavior
- patterned PCs for reversible directed buckling and anisotropic wetting
- time-scale of the wetting transition (dynamics)
- reversibility of the wetting transitions and lifetime of the specimen
- influence of the polymer brush surface free energy vs. influence of the PC topography on the wetting
- influence of the PC-support interaction upon the buckling and dynamic wetting behavior

2.3 Work programme incl. proposed research methods

To address the aims of the project and coordinate our work with our collaboration partners, the work is scheduled in successive work packages (WP).

WP1: Preparation of switchable PCs: Variation of grafting density and thickness

Starting point is our preliminary work on PCs [JO3, JO4] but now combined with the recently developed and significantly improved SIP technique of SI-CuCRP [JO2, JO5-JO8] to prepare PCs with brushes of controlled grafting density, and strictly linear polymer grafts of very low dispersity ($\bar{D} \leq 1.1$). As the "substrate" we will use the carbon nanosheets (crosslinked biphenyl self-assembled monolayers) on solids with terminal amine groups for the coupling of the SI-CuCRP initiator (BIBB see Fig.3). We will perform SI-CuCRP with selected monomers to obtain a first set of switchable PCs. Again we will start with a known system being poly(4-vinylpyridine)-PCs (P4VP-Ps) but now with a defined polymer brush architecture and additional variation of the grafting density as well as the PC thickness. Both can be directly tuned by the SI-CuCRP reaction conditions namely the copper plate-to-substrate distance and the reaction time. The general preparative steps are outlined in Fig. 4.

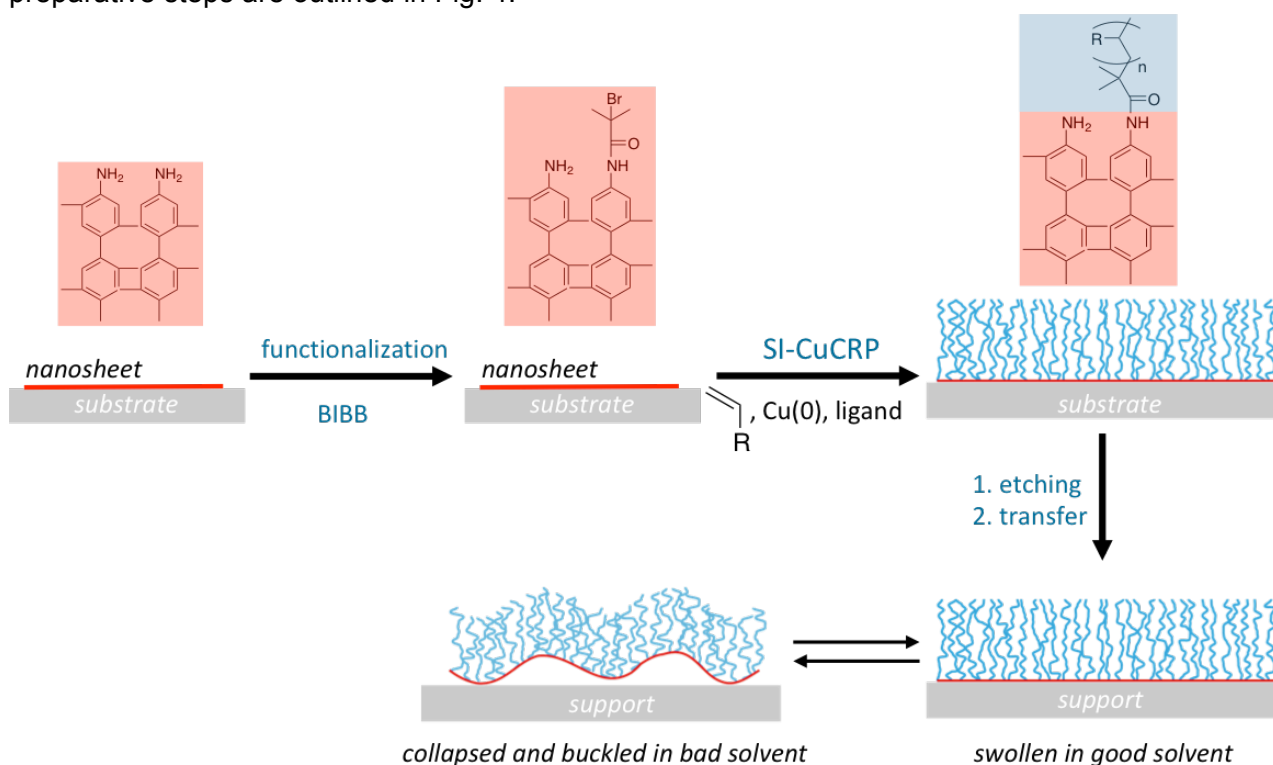


Fig.4: Preparation of polymer carpets: The amine function of a carbon nanosheet is used for the coupling of the SI-CuCRP surface initiator (BIBB). The functionalized sheet is then subjected to the SI-CuCRP with a vinyl monomer of choice for polymer brush formation. This polymer brush system will already be used for comparative wetting experiments (in swollen and collapsed state with no buckling). The brush is then removed from the substrate by etching (KI for Au or HF for SiO₂ substrates) and the detached polymer carpet either transferred to a support (no chemical bonding!) or used as a freestanding PC (e.g. on a TEM grid). The reversible and dynamic buckling and wetting behavior is then studied under good and bad solvent conditions tuned by the wetting liquid itself or additional triggers (solvent, vapor, pH, T).

The buckling behavior, switching and wetting properties (water, ethanol, pH and water/ethanol mixtures) of obtained series of PCs will be measured by static and dynamic contact angle goniometry. By direct comparison with the respective polymer brush system (same sample but before removal from the substrate) will give the influence of the topographic changes (buckling) of the PC wetting behavior. As the buckling scales with strain which in turn scales with the brush grafting density and chain length, we will obtain a systematic insight on the influence of the basic brush parameters of the PCs upon their wetting properties (static, advancing/receding contact angles, hysteresis). In collaboration with the group of H. Riegler (MPI-KG project in this SPP2171), advanced wetting studies of the P4VP-PCs with water/ethanol mixtures will be performed by "time

resolved film thinning microscopy" [7] to elucidate the dynamics of the liquid film dewetting and possibly the onset of the buckling on the millisecond time-scale. In own and collaborative wetting experiments and PC morphology studies we will transfer the PCs on different supports and study the buckling and wetting phenomena as a function of support-PC interaction strength. This can e.g. be done by using silicon wafers modified by different SAMs.

On the preparative side, we will add new PCs featuring the stimuli-responsive polymers poly(N-isopropylacrylamide) (PNIPAAm) (T), poly[(2-(methacryloyloxy)ethyl) trimethyl ammonium chloride] (PMETAC) (pH) and the double responsive poly(2-dimethylaminoethyl methacrylate) (PDMAEMA) (T,pH) to the series and investigate their static and dynamic properties. These system will be of special interest in our SPP2171 collaboration with the Tanaka group to study the liposomal wetting on the attached brush as well as on the flexible PC systems as the above listed polymers have a critical solution temperature in water in an applicable range for liposomes in water.

Taking advantage of the synthetic possibilities of the "on water" SI-CuCRP, we will also add selected PCs with hydrophobic polymer brushes but of low glass transition temperatures [JO8] and investigate their buckling and resulting wetting properties with suitable solvent/water mixtures, analog to the initial P4Vp-PCs. Depending on the results of our wetting experiments, these will also be investigated by the Riegler group.

The wetting characteristics of the soft polymer brush surfaces and, in comparison, the flexible PCs will also be investigated by our SPP2171 collaboration partner S. Karpitschka (MPI-DS, Göttingen). He will study the wetting/interaction of liquid drops on the viscoelastic brushes and PCs (Cheerios effect, drop coalescence) [8, 9]. Furthermore, our polymer brushes with highly defined and the systematic variation of brush parameters and especially the corresponding PCs are ideal systems for a systematic study of their rheological properties using a moving contact line [10]. With both, the Riegler and Karpitschka group we have therefore planned an intense collaboration incl. PhD student exchange.

WP1b: Direct determination of brush parameters

Since the brush parameters chain length, grafting density and polymer dispersion are very fundamental for this project but normally only estimated indirectly by the measurement of the brush swelling ratio [12], we will dedicate a subWP to the direct determination of these values by a wafer-scale synthesis of the respective brush, detachment of the polymer from the substrate and measurement of the average polymer chain length and the dispersion by MALDI-ToF mass spectrometry and size exclusion chromatography. From these values also the true average grafting density can be calculated using the brush scaling laws [11]. We already demonstrated this possibility [JO2] but the determination is rather costly because of the use of *one entire wafer* for each measurement and a tedious collection of the degrafted polymer brush. Therefore, this characterization can only be carried out with selected systems.

WP2: Preparation of patterned PCs - Reversible, stimuli-responsive anisotropic wetting

The use of an initiator-monolayer gives direct access to patterning techniques. As shown before [JO4], we will prepare micropatterned polymer brushes and corresponding supported and/or freestanding PCs using electron beam patterned carbon nanomembranes. Selection of the polymers and brush parameters will depend on the results obtained in WP1. In this WP we will vary the pattern size, shapes and spacing around the expected buckling wavelength of the PCs to manipulate the directed buckling phenomena. Aim of this WP is to maximize the directed buckling effect and therefore maximize a possible anisotropic wetting behavior of the patterned PCs.

Analog to WP1 we will perform static and dynamic wetting experiments to elucidate the anisotropy in wetting of hydrophobic as well as switchable PCs (liquids: water, aqueous organic mixtures;

stimuli: T, pH and solvent quality). An interesting aspect will be also the reversibility of anisotropic wetting as the PC might react by complete folding. A possible anisotropic wetting is of immediate interest to our SPP collaboration partners listed above. Even if the goal of anisotropic wetting can not be realized, we will gain valuable insight on the influence of defined heterogeneities in brush or PC surface on the static and dynamic wetting characteristics. In case this aspect will move into the focus of WP2, we will concentrate on brush patterning with pattern/"defect" dimension that match the polymer surface screening dimension.

WP3: Gradient PCs - Graded buckling and graded wetting

The preparation of gradient polymer brushes by SI-CuCRP simply requires a tilting of the Cu-plate being the polymerization catalyst source [JO2, JO5, JO6, 14]. Smooth or steep brush gradients can be prepared in dimensions that are on the mm-cm scale and thus ideal for wetting experiments using liquid droplets or dip-coating experiments. With polymer candidates developed in WP1, we will prepare graded polymer brushes and respective PCs and investigate their reversible dynamic and static wetting, specifically as a function of their buckling. As our preliminary work showed that the buckling scales with the strain which in turn scales with the brush thickness, also the wetting of liquids should continuously/gradually change along the thickness gradient even through the polymer surface would be chemically the same. These would be exciting and, to the best of our knowledge, the first systems of such kind and should be interesting to gradually and dynamically control wetting and adhesion for technological applications. Analog to WP1 and 2 we will provide such samples to our SPP2171 collaboration partners. As the preparation of graded brushes is so simple, some of the samples listed under WP1 and 2 might be replaced with graded specimen that would allow a higher-throughput screening of the wetting studies as compared to single sample investigations.

WP4: Multiblock PCs - Reversible buckling and surface reconstruction

As time allows, we will take advantage of the unparalleled highly living character of the SI-CuCRP reaction and prepare first samples of di- and triblock polymer brushes and corresponding PCs. We will perform preliminary studies on the wetting properties with water of amphiphilic polymers with a switchable hydrophilic inner and hydrophobic outer block and investigate their morphological changes. Surely, these systems could also be systematically varied as outlined in WP1-WP3 but within 3 years not feasible. However, the multi block systems as well as binary brush and Janus-type PCs are potential candidates for this project in the second phase of the SPP2171.

2.4 Data handling

We will document all experimental procedures as well as all measured data in logbooks. Logbooks will be stored for at least 10 years in a safe way. Data will additionally be stored on the work group server of the Chair of Macromolecular Chemistry of TU Dresden.

2.5 Other information

none.

2.6 Descriptions of proposed investigations involving experiments on humans, human materials or animals as well as dual use research of concern

none

2.7 Information on scientific and financial involvement of international cooperation partners

none

2.8 Information on scientific cooperation within SPP2171

Within the SPP2171 we plan to collaborate with the groups of H. Riegler (MPI-KG, Golm) on the "time resolved film thinning microscopy" and with S. Karpitschka (MPI-DS, Göttingen) on dynamic droplet wetting experiments and rheology of soft surfaces where we provide polymer brush and PC samples for systematic wetting studies using liquids. The planned collaborative work is outlined in the work package descriptions and also involve the intense exchange of students between the groups throughout the first phase of the SPP. Furthermore, we will collaborate with the group of M. Tanaka (Univ. Heidelberg) on the wetting of adaptive polymer carpets by lipid vesicles/liposomes. With M. Tanaka we have a long-standing and highly productive collaborative past (12 mutual publications) that we plan to continue. Finally, collaboration with the group of T. Pfohl (Univ. Freiburg) on the functionalization of his flexible membranes with polymer brushes is planned. Beyond this, we would be happy to provide flexible, adaptive and switchable polymer brushes for the study of dynamic wetting phenomena also to other groups of the SPP2171. As chemists we rely on the expertise of the physics groups within the SPP2171 and looking forward to future collaborations.

3 Bibliography

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4 Requested modules/funds

4.1.1 Funding for Staff

We apply for one position $\frac{3}{4}$ TVL E13 for one Ph.D. student for a duration of three years. A chemist with good knowledge of polymer chemistry and analytics is sought. The student will carry out the project related laboratory work, including surface modification, polymerization, characterization and sample manipulation.

Requested for three years 1 position $\frac{3}{4}$ TVL E13.

To increase the sample preparation and cope with the detailed surface characterization and optimization of polymer carpet/brush parameters with respect to the wetting properties, we ask for a student research assistant. This is foremost a unique possibility for a student to get early insights into different synthetic and analytical procedures of polymer chemistry and surface science and allows us early stage recruiting. The student will assist the PhD candidate in his research.

Requested for three years 1 student research assistant, 20 h/month.

4.1.2 Equipment up to €10,000, Software and Consumables

To carry out the proposed practical work, we apply for basic funding to cover project cost for:

1) Consumables, chemicals and small instruments for the labs at TU Dresden per year:

Glass ware, chemicals, solvents, inert gas (Ar, N₂), tubings, substrates, wafers, AFM-tips.

11 000 EUR

Total costs for consumables for 3 years are 33 000 EUR.

4.1.3 Travel expenses

4.1.3.1 SPP2171 events related travel expenses

As outlined and advised by the organizer of the SPP2171 we would like to participate on all planned SPP2171 events to integrate our research in the program and exchange with the SPP2171 groups. Therefore we apply for funds to cover travel costs for:

1 st year	2 nd year	3 rd year
SPP workshop, PI & PhD, 4 days: 1100 €	SPP workshop, PI & PhD, 4 days: 1100 €	SPP conference (PI & PhD) PI & PhD, 5 days: 1300 €
SPP Advanced School PhD, 5 days: 600 €	PhD candidate workshop PhD, 4 days: 520 €	
1700 €	1620 €	1300 €

Rates are estimated as 80 €/day and person plus 200 € travel/person.

4.1.3.2 SPP2171 collaboration related travel expenses

To enable a close collaboration with our partners within the SPP, H. Riegler at the MPI-KG in Golm and S. Karpitschka at the MPI-DS in Göttingen, we plan kick-off meetings to coordinate the mutual work packages with both groups in the first and short term research stay of the PhD candidate in both groups in the 2nd and 3rd year. The research stays are critical to have students know and work with each other on the common objectives. Additional project coordination meetings will be carried out during the SPP workshops. We apply for funds to cover travel expenses for:

1 st year	2 nd year	3 rd year
Kick-off meeting @ Golm PI & PhD, 2 days: 700 €	Research stay @ Golm PhD, 14 days: 1400 €	Research stay @ Golm PhD, 14 days: 1400 €
Kick-off meeting @ Göttingen PI & PhD, 2 days: 700 €	Research stay @ Göttingen PhD, 14 days: 1400 €	Research stay @ Göttingen PhD, 14 days: 1400 €
1400 €	2800 €	2800 €

Rates are estimated as 80 €/day and person plus 200 € travel/person.

Total costs for SPP collaboration related travel for 3 years are 7000 EUR.

4.1.3.3 Other travel expenses

To disseminate the results of this project we plan to present our work on one national and one international conference. To cover transportation, conference fee and hotel we apply for the following funds:

1 st year	2 nd year	3 rd year
none	National conference PhD & PI, 4 days: 1000 €	International conference PhD & PI, 5 days: 3000 €

Total costs for SPP related and other travel expenses for 3 years are 14720 €.

4.1.4 Project related publication expenses

We apply for 750 EUR per year to cover project related publication costs that arise for "open access" publications, poster presentations, and possible cover pages charges.

4.1.5 Instrumentation

No additional funds for instrumentation exceeding 10.000 or 50.000 € are required.

5 Project requirements

5.1 Employment status information

Jordan, Rainer, W3-Professor, permanent position since 2009, Technische Universität Dresden

5.2 Composition of the project group

Rainer Jordan, Professor W3, funded by TU Dresden
 Daniel Hafner, PhD student, funded by TU Dresden
 Erik Wegener, PhD student, funded by TU Dresden
 Matthias Kluge, CTA /lab assistant, funded by TUD

5.3 Cooperation with other researchers

5.3.1 Researchers with whom you have agreed to cooperate on this project

With the group of A. Götzhäuser (Univ. Bielefeld) we have agreed on a close collaboration for this project. The group will provide crosslinked amino-functionalized biphenyl SAMs (carbon nanomembranes) on gold and silicon substrates as in our past collaboration and will also provide patterned samples.

For collaboration within the SPP2171 please see section 2.8.

5.3.2 Researchers with whom you have collaborated scientifically within the past three years

Alexander V. Kabanov (University of North Carolina at Chapel Hill, USA; Lomonosov Univ. Moscow, Russia), Asutosh Chilkoti (University of North Carolina at Chapel Hill, USA), M.G. Finn (Georgia Tech, USA), Nicole Steinmetz (Case Western, USA), Helena Florindo (University of Lisbon, Portugal), Christine M. Papadakis (TU München, Germany), Tao Chen (Ningbo University, China), Robert Luxenhofer (Universität Würzburg), Dietrich Zahn (TU Chemnitz), Armin Götzhäuser (Universität Bielefeld, Germany), Yusuf Yacgi (Istanbul Technical University, Turkey), Christoph A. Naumann (Univ. Purdue, USA).

5.4 Scientific equipment

The Chair of Macromolecular Chemistry at TU Dresden is equipped with all needed infrastructure for the synthesis, purification and characterization of monomers, complex polymers, polymer analog reactions, purification steps and surface analysis. This includes lab space, hoods, offices, Schlenk-lines, glove-box, UHV reaction set-up, MALDI-ToF MS, GPC etc. For surface characterization the chair is equipped with a spectral ellipsometer, computer-aided contact angle goniometer (Krüss) with an environmental chamber (control of temperature and vapor phase) and an AFM (NT-NDT) as well as an AFM-coupled to a confocal RAMAN and fluorescence spectrometer with a high time and lateral resolution. Moreover, the AFM setup is equipped with an advanced liquid and gas cell for surface investigation under various solvent, vapor and temperature conditions. Samples will also be investigated with our optical epi-fluorescence microscopy setup (Zeiss) tailored for materials science experiments.

5.5 Project-relevant cooperation/participation with/in commercial enterprises

none

6 Additional information

There is no relation between the proposed project and projects in a collaborative research center at TU Dresden or any other project currently ongoing at the Chair of Macromolecular Chemistry at TU Dresden. No proposal for financial support of this project has been submitted elsewhere. In case we submit such a proposal, we are going to notify Deutsche Forschungsgemeinschaft immediately. The TU Dresden was informed of the submission of the present proposal.